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Monthly last-page interview with people who help to shape the PC industry.

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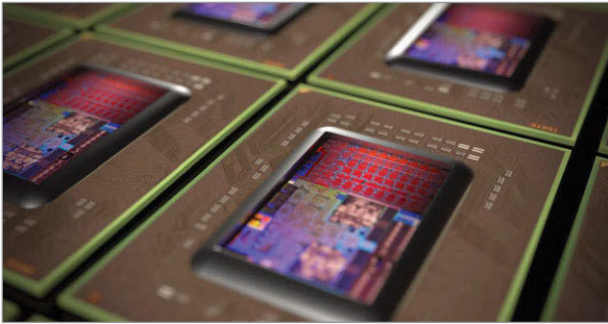
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Lincoln, NE 68501
or
120 W. Harvest Drive
Lincoln, NE 68521

Advertising: (800) 247-4880
Fax: (402) 479-2104

Circulation: (800) 334-7458
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Next-Generation AMD APUs, Code-Named "Carrizo," Focus On Efficiency

AMD has begun trickling out details on the generation of APUs that will succeed Kaveri. Code-named "Carrizo," the new processors will have approximately the same die size, but make use of 3.1 billion transistors, nearly 29% more than Kaveri. They also will have new x86 CPU cores called "Excavator" and a new version of Radeon GPU cores. The company says the Excavator cores will make use of more instructions per clock cycle but use 40% less energy, and that overall the Carrizo line of APUs should provide "double-digit increases in both performance and battery life." The processors are being aimed at notebooks as well as the low end of the desktop market. Other notable achievements for Carrizo include being the first line of APUs from AMD that integrate the Southbridge, the first to include support for the H.265 video standard, and the first processor line in the industry to meet the HSA 1.0 specification that promotes more efficient computing.

Look Out, Below: FAA Gives OK For Amazon To Begin Testing Drones

The Federal Aviation Administration announced recently that it was issuing an "experimental worthiness certificate" to the division of Amazon that the company has tasked with exploring the delivery of consumer goods by drones. Don't expect to get that late night "I've run out of ink and need a new cartridge right away" emergency taken care of by aerial delivery just yet, however. The FAA says it issued the certificate with provisions that require all flights to be made under 400 feet, in daylight, in good weather, and within visual sight of the drone operator. Oh, and anyone operating the drones must have, at the minimum, a pilot's license *and* medical certification (no, we're not sure what the deal is with that last one, either). Amazon also must provide the FAA with regular flight reports. With all that, we're guessing deliveries will be made by four-wheeled vehicles for some time to come.



WATCHING THE CHIPS FALL

Here is the pricing information for various AMD and Intel CPUs.

CPU	Released	Original Price	Last Month's Price	Online Retail Price*
AMD FX-9590 Eight-Core	6/11/2013	N/A	\$239.99	\$239.99
AMD FX-9370 Eight-Core	6/11/2013	\$375	\$219.99	\$219.99
AMD FX-8350 Eight-Core	10/23/2012	\$195	\$179.99	\$179.99
AMD FX-8320 Eight-Core	10/23/2012	\$169	\$149.99	\$144.99
AMD FX-6350 Six-Core	4/30/2013	\$132	\$125.99	\$120.99
AMD A10-7850K Quad-Core	1/14/2014	\$173	\$149.99	\$149.99
AMD A10-7800 Quad-Core	7/2/2014	\$153	\$141.99	\$145.99
AMD A10-7700K Quad-Core	1/14/2014	\$152	\$129.99	\$129.99
AMD A10-6800K Quad-Core	6/4/2013	\$142**	\$129.99	\$124.99
AMD A10-5800K Quad-Core	10/2/2012	\$122**	\$99.99	\$99.99
Intel Core i7- 5960X Eight-Core	8/29/2014	\$999**	\$1,049.99	\$1,049.99
Intel Core i7- 4960X Six-Core	9/3/2013	\$990**	\$1,025.99	\$1,032.27
Intel Core i7- 5930K Six-Core	8/29/2014	\$583**	\$579.99	\$579.99
Intel Core i7- 4930K Six-Core	9/3/2013	\$583**	\$579.99	\$549.99
Intel Core i7- 5820K Six-Core	8/29/2014	\$389**	\$389.99	\$389.99
Intel Core i7-4790K Quad-Core	6/25/2014	\$339**	\$319.99	\$339.99
Intel Core i7-4770K Quad-Core	6/2/2013	\$339**	\$349.99	\$339.99
Intel Core i7-4820K Quad-Core	9/3/2013	\$323**	\$319.99	\$327.29
Intel Core i7-4790 Quad-Core	5/11/2014	\$303**	\$304.99	\$309.99
Intel Core i5-4690K Quad-Core	6/3/2014	\$242**	\$234.99	\$239.99

* As of March 2015

** Manufacturer's estimated price per 1,000

Corsair Releases Special Dominator DDR4 Tuned For GIGABYTE Board

Take an X99 motherboard specifically made to set speed records, add a DDR4 kit specifically made for that board, and what do you get? World records, of course. Corsair has released kits of its Dominator Platinum Series 3400MHz DDR4 Memory that are specially tuned for the GIGABYTE X99 SOC Champion motherboard. The 16GB (4 x 4GB) kits have already been used with the X99 SOC Champion to set a world record (4365.6MHz) for DDR4 memory. (Note that if you want to set a new record, you'll need to get some liquid nitro.) MSRP for the Dominator kit is \$999.99.



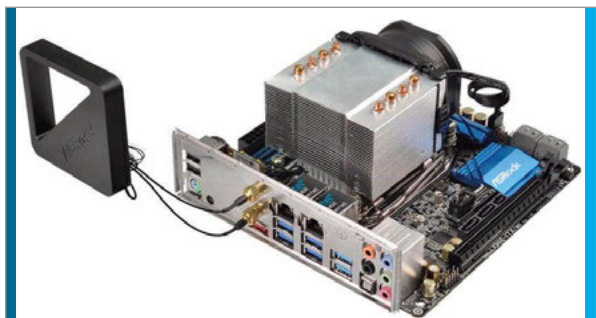
These Mothers Are Built For Speed: GIGABYTE X99 Champion Series

GIGABYTE has taken four of its X99 motherboards and created special high-performance versions by including support for higher frequency memory. The company calls this group of boards its "X99 Champion Series," and the motherboards it comprises are the X99-Gaming 5P, X99-UD4P, X99-UD3P, and the X99-SOC Champion. All the boards support memory speeds up to DDR4-3200, and one board, the X99 SOC Champion, supports up to DDR4-3400. For an extended look at the X99 SOC Champion that includes benchmarks, see this issue's Heavy Gear section.



World's First Mini-ITX Mobo With X99 Chipset: ASRock X99E-ITX/ac

ASRock has created a mini-monster of a motherboard by packing the X99 chipset onto a Mini-ITX frame. The ASRock X99E-ITX/ac has an LGA2011-v3 socket and supports Intel Core i7 Haswell-E as well as 18-core Intel Xeon processors. The board ships with a cooler to fit the 2011-3 socket and has two DIMM slots that support up to 32GB DDR4-3200+ memory. It also has two USB 3.1, six USB 3.0, one PCI-E 3.0 x16, Intel Dual Gigabit LAN, 2T2R 802.11ac WiFi, 7.1 CH HD Audio, six 6Gbps SATA, and Ultra M.2. Price was not yet available at press time.



MSI Offers Unique Twist With GS30 Shadow Notebook & Gaming Dock

Mobility or speed? Most gamers have to decide which feature is more important to them, as more powerful components usually require more room. But MSI is offering a new take on mobile power with its GS30 Shadow with Gaming Dock. The dock has its own PSU and 3.5-inch drive bay, and it has a PCI-E 3.0 x16 slot that can handle a regular desktop graphics card. You can use the dock to add storage and/or upgrade to the latest GPU. Use the notebook by itself for mobile gaming (4th gen Intel quad-core i7 CPU; Intel Iris Pro Graphics 5200) or dock for more power.



New "Performance Edition" G303 Daedalus Apex Mouse By Logitech

Gamers require responsive input devices for their pastime. They want speed, flexibility, and style. Logitech solicited feedback from gaming enthusiasts and then used that data to create the G303 Daedalus Apex Mouse. The G303 uses Logitech's most advanced optical sensor and features a proprietary metal spring tensioning system that keeps the mouse lightweight and responsive. Throw in six programmable buttons and the customizable lighting options, and the G303 Daedalus gives gamers the ability to frag their way through games in style. It should be out soon.



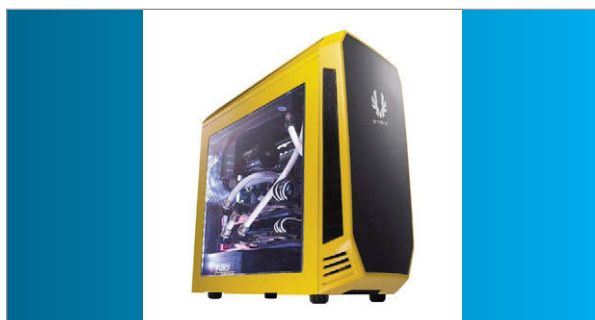
New Mini-ITX Case On The Way: Cougar QBX Arrives at Retail Soon

Cougar is coming out with what it says will be the most advanced compact case on the market. The company says its new QBX Mini-ITX case has expandability and cooling features that outshine those of other products in the category. The QBX measures 10.24 x 7 x 14.49 inches (HxWxD) and handles graphics cards up to 13.78 inches long. The case has a separate airflow for the PSU to isolate hot air and can handle up to seven fans or a reservoir up to 240mm for liquid cooling. It has space for up to five HDDs/SSDs. The QBX should be available sometime this month.



BitFenix Officially Launches AEGIS Chassis It Demoed At Computex

The AEGIS case from BitFenix is aimed at the growing legion of microATX and Mini-ITX enthusiasts. This tool-less case measures 18.50 x 8.07 x 18.89 inches (HxWxD) and comes in five colors (black, white, yellow, red, and blue). It's made of steel and polymer and has an acrylic side window. There are four 3.5-inch drive slots (two removable cages), four 2.5-inch drive slots (one removable cage and two interior slots), and five PCI slots. The case handles graphics cards up to 14.9 inches long and CPU coolers up to 6.7 inches high. A fan controller is included. The AEGIS retails for about \$119.



Silverstone PS11B-W: An Entry-Level Case Made For Enthusiasts

Not everyone needs (or can afford) a top-of-the-line case for every build. Sometimes you just want good quality at a decent price, which is where Silverstone's PS11B-W shines. This steel and mesh ATX tower case includes a side panel window, has seven expansion slots, and can handle huge graphics cards (up to 16.2 inches). Up front there are two 5.25-inch drive bays on top with tool-less locks; three tool-less 3.5-inch drive bays on the bottom, and two 2.5-inch bays in between. The interior is painted black, and the mobo tray is cut out for easy CPU cooler assembly. You can find this case at retail for under \$65.



NASA Releases Asteroid Hunting Software To Amateur Astronomers

In 2014, NASA held a contest that provided prizes to individuals who helped improve various algorithms the agency uses to identify asteroids in images captured by telescopes. Now the agency has taken variations of those algorithms and combined them into an application that's free for amateur astronomers around the globe to download. The "Asteroid Data Hunter" application can scan photos that people download to their computers from their personal telescopes and identify new asteroids. It's available for download at www.topcoder.com/asteroids.



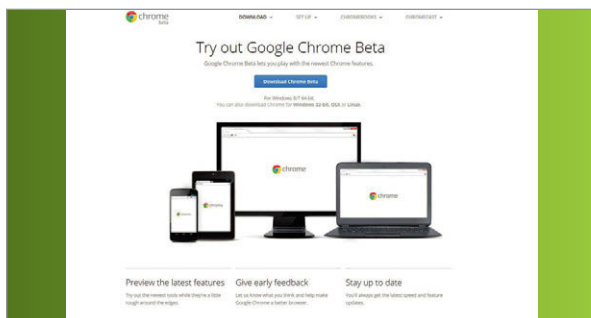
Apple Releases Fourth Beta Version Of iOS 8.3 To Developers, Public

Practice makes perfect. It's what your baseball coach told you in eighth grade, and it's apparently what Apple is telling fans of its iOS operating system. A fourth beta for iOS 8.3, the next version of the software that runs on hundreds of millions of Apple iPhones and iPads, has been released by the company. Although this is the fourth version Apple has supplied to developers, it's only the second one they have sent into general release for the public. If you're interested in seeing what new features are in store for iOS, register for the beta program at <https://appleseed.apple.com/sp/betaprogram>.



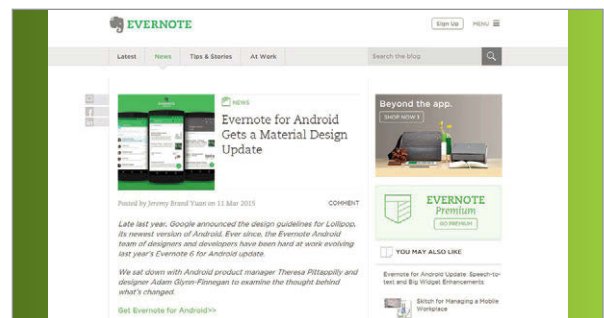
The Answer To Life's Questions? Google Releases Chrome 42 Beta

The latest beta release of the Chrome web browser, version 42, is now available for download. According to the Chromium blog, Chrome 42 beta has some interesting new features, including APIs that will allow website developers to push information to your screen even if the browser is closed, providing you have given your permission. Another new feature is a banner that lets Android users automatically add frequently visited apps to their homescreens. You can check out these new features by downloading the latest betas at <https://www.google.com/chrome/browser/beta.html>.



Evernote 6.0 For Android, Released In 2014, Gets A Lollipop Facelift

People who scribble notes here, there, and everywhere are often big fans of Evernote, the note-taking app that lets you take a note on one device and then access it (and add to it) on another. Evernote just came out with an updated version for Android, making design changes to align the look and feel of the software more with what Google recommends for the latest flavor of Android, Lollipop. (The most recent version of which came out in March.) Officials at Evernote say they try to tailor each software version to its platform to take advantage of unique features and improve usability.



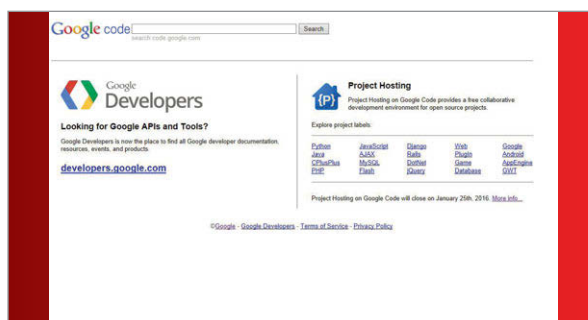
Microsoft Announces It Will Begin Phasing Out Internet Explorer

Microsoft intends to replace its veteran browser, Internet Explorer, with a product code-named "Spartan" that will arrive with the introduction of Windows 10. IE was born in the early days of the web and famously battled (and eventually vanquished) browser pioneer Netscape, but in recent years has seen its market share eroded by more nimble competitors. While some IE code likely will remain in Win10 for compatibility reasons, Spartan will become Microsoft's main browsing product. Spartan will include the Cortana web assistant that is Microsoft's counter to Apple's Siri.



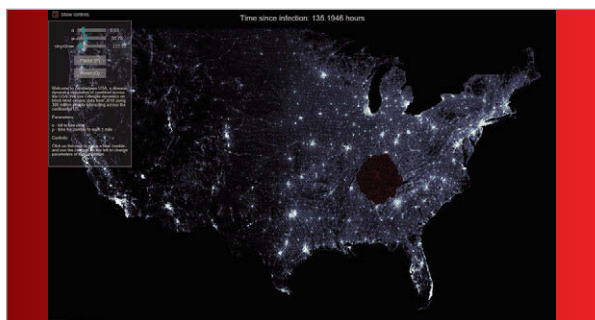
Google Code Winds Down; Service To Shut Down Entirely In 2016

Google has announced it intends to shutter Google Code, a website that hosted open-source projects and provided a place for coders to collaborate and share information. The company said it would close the site in phases and started by disabling new project creation as of March 12. Other key dates include August 24 of this year, when the site will become read only, and January 25, 2016, when the hosting service shuts down. Google will keep the site open for downloads of source code and the like for the remainder of 2016 before shuttering the site entirely.



Surprise! Stay Away From Big Cities If You Want To Avoid Zombies

Cornell graduate students Alex Alemi and Matt Bierbaum have created a website called Zombietown, USA, that simulates how zombies would spread across the U.S. in an infection scenario. The website lets you adjust certain factors such as the speed of the zombies and their "kill to bite" ratio, and then you plant a zombie on the map and watch to see how fast things develop. The dynamic simulation keeps track of elapsed hours since the infection. It's all in good fun (this must be what physics doctoral students do in their spare time). Check out the site here: bit.ly/1BmETYY.



Senate Advances Cybersecurity Information Sharing Act Of 2015

The Cybersecurity Information Sharing Act, or CISA, moved another step closer to becoming law after a Senate committee voted behind closed doors to advance it. Proponents of the bill say it would help protect people from massive hacking attacks as it promotes the sharing of information between the government and companies when security breaches occur; opponents say it simply gives the government another way to gather information about citizens without restrictions on what it does with the data. Expect lots of pro/con arguments this year as the bill moves forward to a final vote.





Job Of The Month

PayPal, the subsidiary of eBay that is scheduled to be spun off from the mothership as a separate company sometime in the second half of this year, operates one of the largest online payment systems in the world. eBay/PayPal is currently looking for a Voice Application Development specialist at its operations center in Omaha, Neb. This person will work with other business units on IVR-related projects and will be responsible for VXML development and related tasks, including network architecture design and capacity and facilities planning, which includes site facility planning for voice. The person in this position also will evaluate hardware/software, work with vendors, and handle other duties related to the voice applications network. You must have five years of development experience and ideally will have serious skills with C/C#, .NET, VXML, XML, SQL/rDBMS and related areas. If you're into voice applications and fancy living in Omaha, give the company a shout.

jobs.ebayinc.com

Uncle Sam Wants YOU! (Or At Least Your Data)

Two years ago, documents leaked online by Edward Snowden revealed the existence of massive government surveillance programs in the U.S. Regardless of how they feel about what Snowden did, many Americans are at least somewhat uncomfortable with the idea that their communications and other activities online may be monitored. A new survey from the folks at Pew Research Center showed that one in four people say they have actually made some changes to how they use things such as cell phones, social media, and the Internet, because of the possibility the government might be watching.

www.pewinternet.org

Changing Behavior

Percentages of people who adjusted their behavior in the following areas because of security concerns about government surveillance programs:

email accounts	18%
Search Engines	17%
Social Media	15%
Cell Phones	15%
Mobile Apps	13%
Text Messages	13%
Landline Phones	9%
Any of the above	25%

Driverless Cars? Gramps Isn't Crazy About Them

Self-driving vehicles may be ready for mass consumption in the near future, but that doesn't mean the public will be ready to use them. Harris Interactive surveyed people about how comfortable they were with the concept of self-driving cars. It turns out there is a pretty even split between those who are OK with the idea and those who aren't sure about its safety. In general, the survey also revealed a correlation between age and comfort level: the older you are, the less likely you are to trust the technology.

Percentage Of Age Group Who Feel Autonomous Cars Would Be Either "Very Safe" Or "Somewhat Safe" For People In These Three Situations

	Millennials (18 - 37)	GenX (38 - 49)	Boomers (50 - 68)	Matures (69 +)
1. People inside car	53%	47%	46%	39%
2. Other drivers nearby	49%	43%	41%	31%
3. Pedestrians nearby	44%	39%	37%	27%

www.harrisinteractive.com



RAW Numbers:

31%

Percentage of higher education students nationwide who take at least one of their classes online.

Babson College

42%

Percentage of people in a survey of 31 emerging and developing nations who said they feel the Internet is a bad influence on morality.

Pew Internet Research

300

Number of hours of video that are uploaded to the video website YouTube every minute.

YouTube

\$5.4 billion

Total forecast value of global revenues from connected fitness trackers in the year 2019.

Parks Associates

205 billion

The number of email messages sent and received each day. Of this total, 93 billion are consumer-related messages and 112 billion are business-related messages.

The Radicati Group

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Intel NUC

The Shape Of Things To Come



Intel's diminutive NUC (Next Unit of Computing) desktop PCs have been through a number of changes in the years since their introduction; many of the revisions consisted largely of upgraded CPUs and, more recently, the option to install a 2.5-inch SSD or HDD inside. The newest NUC units have new Fifth Generation Core Intel processors and the 2.5-inch drive option, the most powerful processor graphics ever built, and an all-new feature that makes NUC the most customizable, forward-thinking computer system designed to date.

Under The Hood

The latest NUC model, NUC5i7RYH, is the first NUC ever available with a Core i7 processor, namely the Core i7-5557U. This chip is a dual-core Broadwell CPU that runs at 3.1GHz (3.4GHz Turbo), has a 4MB Intel Smart Cache, and boasts a stingy 28-watt TDP. The 5557U also packs an amped-up Intel Iris Graphics 6100, which supports 4K displays and has posted 30% increases in graphics performance (based on 3DmarkVantage and 3Dmark11) over its predecessor, the 28-watt Haswell part.

That makes this the best NUC for gaming ever, and Intel Graphics have been gaining ground in the gaming market for several years now. According to Steam's Hardware Survey, use of Intel Graphics among Steam gamers increased from 6.2% in late 2010 to nearly 19% by the end of 2014. In other words, nearly one in five gamers on Steam were running Intel Graphics prior to 2015, and those numbers are likely to increase thanks to continually increasing performance.

The NUC5i7RYH also comes with up to 7.1 surround audio via its Mini HDMI and Mini DisplayPort connections, a total of four USB 3.0 ports (two on the



front panel and two in the back), Gigabit Ethernet support, Wi-Fi and Bluetooth wireless connectivity, and a wall-mount AC-DC power adapter.

Memory & Storage

Considering all that you get with the NUC5i7RYH, it's easy to forget that it's a kit. But there are a couple things you

Advertisement



will need to bring to the party to get the NUC ready to rumble. The first is system memory; the unit supports up to 16GB of dual-channel 1,333MHz or 1,600MHz DDR3L. And remember, the NUC is only about 4 inches square, so you'll be looking for SODIMMs.

You'll also need to secure a storage device, but you'll have plenty of options. You can add an M.2 SSD to the NUC5i7RYH, and it will also accommodate a 2.5-inch SSD or hard drive. That means you could potentially outfit your NUC with a boot drive up to 1TB in size *and* a data drive that holds 2TB or more of media files and less speed-intensive applications.

Your NUC, Your Lid

Because the NUC is very small and is VESA mount-compatible, it's pretty easy to tuck it completely out of sight if that's what you want to do. But some

people like to personalize their computers, whether that takes the form of a custom paint job or their favorite stickers, and this is as true of notebooks and other portable devices as it is of full-tower desktop PCs. The NUC provides an all-new way to personalize your PC: You can swap out its black plastic lid for one that you like better.

Intel says it has worked with third-party companies to offer custom lids; some of these will be cosmetic, while others will be functional add-ons that give your NUC wireless charging capability or NFC (near-field communications) connectivity. Cosmetic and functional third-party lids are both interesting, but there's a third option that extremely tech-savvy users may like even more.

Intel's NUC website (www.intel.com/nuc) contains a page on replacing the stock NUC lid with a custom one (intel.ly/1CwMw4U).

Part of the way down the page, you'll find a link to mechanical drawings of the lid that you can download as a PDF if you like. There's even a "Print Your Own Lid" section on the page that lets you download the 3D printer files you'll need to create your very own NUC lid. The possibilities are nearly limitless.

The Biggest Little PC Ever

If you've been intrigued by NUC kits in the past but wanted more power for gaming, home theater, content creation, and myriads of other computing tasks, your NUC is here. The NUC5i7RYH has the most powerful CPU, the most powerful graphics, and the most flexible storage capabilities yet. Add to that the ability to swap out the unit's stock lid for a third-party custom lid or one that you make on your own 3D printer, and this NUC is the one that fits your life. ■

The 1080p Gaming Powerhouse

A Trio Of GeForce GTX 960s For Your Consideration

When it comes to NVIDIA's latest Maxwell GPUs, the powerful GeForce GTX 970, 980, and the TITAN X have been consuming a majority of the oxygen in the room of late. Lest we forget, Maxwell made its debut as the GeForce GTX 750 and 750 Ti back in February of 2014, with maximum TDPs of just 55W and 60W, respectively. Now that we've seen Maxwell shine at the high end and entry level, it's time to see how this chip performs in the middle.

Under the hood of the GeForce GTX 960 you'll find the 2.94 billion-transistor Maxwell GM206 chip paired with either 2GB or 4GB of GDDR5 memory, which runs on a 128-bit bus. Although that seems rather narrow, let's keep in mind the 980 and 970 make due with a 256-bit memory bus. (Only the TITAN X can be said to have a particularly wide memory bus at 384 bits). Consider the fact that AMD's flagship R9 290X graphics card features a 512-bit memory bus. NVIDIA's third-generation lossless Delta Color Compression is the key to letting this card rapidly and efficiently render the scene's colors. All told, this card offers 112GBps of memory bandwidth. When it comes to performance in games, the GTX 960s equipped with 4GB of GDDR5 will handle higher resolutions better than those with the 2GB of memory, but for the most part this card is ideal for gamers who play at 1,920 x 1,080.

There are eight SMMs in this GPU, for a total of 1,024 CUDA cores, 64 texture units, and 32 ROPs. If you're



GeForce GTX 960 AMP! Edition

\$209.99 | ZOTAC | www.zotac.com

keeping track, this graphics card has exactly half the functional units as the GTX 980. As we've mentioned before, NVIDIA reports that Maxwell offers twice the performance per watt compared to Kepler, which goes a long way toward explaining why this graphics card has a mere 120-watt TDP yet delivers such respectable gaming performance.

The GeForce GTX 960 reference design's base core clock is set to 1,127MHz, and the boost clock is set to 1,178MHz. All three cards we

tested come with factory overlocks. The stock memory clock, on the other hand, was left largely untouched on all four cards, at 1,752MHz, quad-piped.

If you're in the market for a gaming workhorse that won't break the bank, any one of these cards will do an exceptional job.

ZOTAC GeForce GTX 960 AMP! Edition

The most striking thing you'll notice about ZOTAC's card is its size. At just 8 inches long, this thing is downright



GTX 960 GAMING 2G

\$219.99 | MSI | us.msi.com

tiny, especially compared to the 11.75-inch-long GeForce GTX 960 from GIGABYTE. The fan shroud on this card is attractive. It's composed of a decorative metallic charcoal painted aluminum faceplate attached to the more structurally important Carbon ExoArmor frame, which ZOTAC first introduced on its GeForce GTX 980 AMP! Edition.

As we went to press, this card was available for \$10 more than ZOTAC's stock-clocked card. For that extra Hamilton, the AMP! Edition 960 gives you an engine clock bump from 1,177MHz (base) and 1,240MHz (boost), to 1,266MHz (base) and 1,329MHz (boost). The 7,010MHz

memory clock is the same between both cards, but ZOTAC's AMP! Edition also comes with a backplate protecting the PCB. Attached directly to the GPU is a fairly traditional heatsink with aluminum fins and a pair of copper heatpipes. There are two 90mm fans in the card's IceStorm cooler, and ZOTAC's FREEZE technology disables the fans when the card is idle. Even under load, however, this card remained extremely quiet.

To power the GTX 960 AMP! Edition, you'll just need a single 6-pin PCI-E power connector. A minimum 400-watt PSU is recommended. The card features a single SLI connector on the top edge so it's ready for 2-way

SLI. On the back bracket, you'll find three DisplayPort 1.2 outputs, an HDMI 2.0 port, and a dual-link DVI port. In the box, ZOTAC includes a dual 4-pin Molex to 6-pin PCI-E adapter. The card has a two-year standard warranty, but you can get the three-year extended warranty by registering the card within 30 days of your purchase.

The ZOTAC GeForce GTX 960 AMP! Edition is built to hit the sweet spot, and as such, its target screen resolution is 1080p (1,920 x 1,080). In the game tests at these resolutions, this card posted scores that were right in line with GIGABYTE's card. If you want a solid factory overclock,

then this card is a good choice. The limited input power and smaller heatsink of this one may limit what DIY overclockers are able to achieve, however.

MSI GTX 960 GAMING 2G

MSI's take on the GeForce GTX 960 is a two-fan model like ZOTAC's, but its Twin Frozr V cooler features slightly larger 100mm fans. The TORX fans feature traditional smooth blades interspersed with blades that have a unique bulge, which are designed to maximize downward air pressure and dissipate air more rapidly, respectively. According to MSI, the fans are capable of 19% more airflow without increased drag, which makes for a cooler GPU and a quieter gaming experience.

The shroud consists of red and black plastic bolted to the top of the heatsink. There are four nickel-plated Super Pipe heatpipes, one of which is a large 8mm in diameter. Zero Frozr technology lets the fans remain motionless when the card is idle. We also like the LED-lit MSI GAMING Dragon logo on the top edge of the card. Although there's no backplate on this graphics card, there is a thick aluminum plate that resides between the heatsink and the PCB that provides some added rigidity to the card.

Under that impressive heatsink is a factory-overclocked GPU that can run in three modes—Silent Mode, which uses the GTX 960's stock clocks; Gaming Mode, which pushes the core to 1,190MHz and the boost clock to 1,253MHz (the default setting and the one we used in the benchmarks); and OC Mode, which uses a 1,241MHz core clock and a 1,304MHz boost clock.

Given that impressive overclock, you might not be surprised that this card features an 8-pin PCI-E power port, and according to the box, you'll need 400-watt PSU with at least one 42A 12V rail. The card is constructed with MSI's Military Class components, which include

Specs & Scores	ZOTAC GeForce GTX 960 AMP! Edition	MSI GTX 960 GAMING 2G	GIGABYTE GV-N960G1 GAMING-2GD
Price	\$209.99	\$219.99	\$209.99
Core clock	1,256MHz (1,329MHz Boost)	1,190MHz (1,253MHz Boost)	1,241MHz (1,304MHz Boost)
Memory clock	1,752MHz	1,752MHz	1,752MHz
Memory interface	128-bit	128-bit	128-bit
Memory	2GB GDDR5	2GB GDDR5	2GB GDDR5
3DMark Professional (Fire Strike Extreme)	3525	3496	3549
Graphics Score	3601	3577	3629
Physics Score	16032	16132	16022
Combined Test	7.04	6.94	7.08
Unigine Heaven 4.0			
Score	753	751	751
FPS	29.9	29.8	29.8
Games	1,920 x 1,080		
Metro: Last Light (16XAF)	52	50.33	52
Aliens vs. Predator (4XAA, 16XAF)	55.4	55.1	55.4
	2,560 x 1,600		
Metro: Last Light (16XAF)	30.99	31	31.33
Aliens vs. Predator (4XAA, 16XAF)	31.1	30.8	31.1
Test system specs: Processor: Intel Core i7-5960X; Motherboard: GIGABYTE X99-Gaming G1 WIFI; RAM: 16GB ADATA DDR4-2400; Storage: 240GB OCZ Vertex 3 MAX IOPS SSD; OS: Windows 8 Pro (64-bit)			

Hi-c capacitors, Super Ferrite Chokes, and solid caps. There are five ports on this card, including one dual-link DVI-I port, three DisplayPort 1.2 outputs, and an HDMI 2.0 port.

We also like MSI's easy-to-tweak Afterburner software, which lets you run with the presets or do your own overclocking. Given the size of the heatsink and the extra power, you can't do much better if you want a GTX 960 capable of hitting some high clocks. The card comes with a two-year labor warranty and a three-year parts warranty. Although this card scored right in line with the rest, you should

be able to put some distance between it and the others with some manual tweaking.

GIGABYTE GV-N960G1 GAMING-2GD

If this was a competition to make the biggest GeForce GTX 960, GIGABYTE would take home the prize. At almost 12 inches long, this thing doesn't look much different than GIGABYTE's GeForce GTX 980 and 970 cards. There are three 75mm fans in the Windforce 3X cooler and a long block of aluminum fins that extends more than two inches past the PCB. Four copper heatpipes run through the heatsink and converge over the

GPU. The fans feature unique ridges that are designed to enhance airflow, reduce air turbulence, and keep the card quiet even while running flat out. The heatsink shroud consists of a piece of anodized black aluminum, and the backplate features a similar piece of black aluminum.

Like MSI, GIGABYTE also included a nifty LED-lit logo; this one says “WINDFORCE” on the top edge of the heatsink. When the card is idle, unique “Silent” and “Stop” indicators light up. This is a nice feature, especially because our hearts tend to skip a beat whenever fans stop spinning while the system is still running.

The GPU in this card has been factory-overclocked to 1,241MHz for the core and 1,304MHz for the boost clock. GIGABYTE differentiates its card from the rest in a handful of ways. One of those is through its GPU Gauntlet Sorting, which

amounts to selecting the GPUs that perform better, both in terms of energy efficiency and overclocking headroom. Speaking of headroom, GIGABYTE installed a pair of 6-pin PCI-E power connectors, and according to the box, you’ll need at least a 400-watt PSU to run the card.

The back panel of the graphics card is another area where GIGABYTE added something special. There are three DisplayPort outputs, one HDMI port, and two DVI ports. These correspond to GIGABYTE’s Flex Display technology, which lets you connect up to four displays. Although you can play games using multiple displays and ultra-high resolutions, the 2GB frame buffer on this card will quickly fill up with some of the more demanding DX 11 games currently available.

GIGABYTE’s GTX 960 also features Ultra Durable VGA technology, which consists of a 2-ounce copper

PCB, Japanese solid state caps, a lower RDS(on) MOSFET design, and metal core chokes. All this helps this card perform better, run cooler, and overclock more reliably.

In the benchmarks, this card’s performance landed it right between the sky-high overclocked ZOTAC card and the lower-clocked MSI card. But like the MSI card, there’s a heck of a lot of room for improvement using GIGABYTE’s OC GURU II overclocking software.

Your Gaming Needs Covered

The GeForce GTX 960, no matter what form it takes, has a lot to offer gamers without deep pockets. That being said, each of the cards we tested offers a handful of unique features that make it appealing in different ways. With so many choices, the hard part will be just picking the one that works best for you. ■



GV-N960G1 GAMING-2GD

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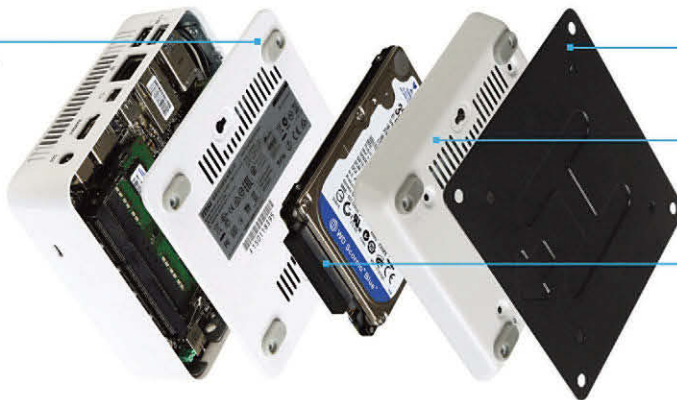
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GIGABYTE GA-X99-SOC Champion

GIGABYTE designed the GA-X99-SOC Champion to break world records, and if you take a quick peek at some of those records that use Intel's Haswell-E processors and DDR4 memory, it's clear that competitive overclockers have put the motherboard to good use. One of the biggest reasons the GA-X99-SOC Champion is tearing down DDR4 world records is the SMT (surface mount technology) used on DIMM slots, which shortens trace paths for improved signal quality and faster communication with the CPU. The GA-X99-SOC Champion supports DDR4 memory modules rated to operate at DDR4-3400, and there are plenty of add-ons for CPU overclocking, too.

With the GA-X99-SOC Champion, the LGA2011-v3 processor socket is fitted with 2,083 pins to take advantage of all the contacts found on Intel's Haswell-E processors for more stable overclocks. A CPU Mode switch lets you switch between Default (2,011 pins) and OC (2,083 pins) modes.

There's a cluster of buttons, switches, and voltage read points to simplify the overclocking process. Onboard power, reset, and clear CMOS buttons are all here, of course, as well as two BIOS switches. The DualBIOS switch lets you move between the Single and Dual BIOS mode, while the BIOS switch lets you change between the main and backup BIOS. The BIOS switch is perfect for situations where you want to maintain default settings while having another BIOS to play around with overclocking settings.

To let you check component voltages in real time, there is an array of read points where you can connect a multimeter. Compared to the options we've seen from GIGABYTE in the past, the GA-X99-SOC Champion offers a few more memory voltage options, such as DIMM_A, DIMM_B, DDRVTT_A, DDRVTT_B. We also like that GIGABYTE includes voltage check points for the PCH.



Overclockers using liquid nitrogen will also like the inclusion of the OC Trigger switch, because it'll help overcome boot issues that can occur at high frequencies. For instance, you can let the system boot at a normal frequency and switch to your target frequency when it's time to capture and validate world records.

To best support multi-GPU configurations, the GA-X99-SOC Champion has a 6-pin PCI-E power connector above the top PCI-E x16 slot. When two or more graphics cards are installed, GIGABYTE recommends pumping extra power to the PEG slots by connecting this onboard power connector to your PSU. GIGABYTE also enhances the PCI-E lanes with an onboard clock generator

to make use of all 40 PCI-E lanes at the disposal of Intel's Core i7-5960X and Core i7-5930K CPUs.

Overall, GA-X99-SOC Champion provides you with four PCI-E x16 slots, two that can run at the full x16 speed and two that run at x8. GIGABYTE smartly splits the layout of the x16 and x8 lanes, so a standard (2x) SLI or CrossFire setup would take up the first and third PEG slots and provide maximum breathing room. A full 4-way SLI or CrossFire setup would run at x8/x8/x16/x8, while a 3-way configuration would run at x16/x16/x8.

Overclockers and cutting-edge technology go hand in hand, so it's no surprise to see that GIGABYTE loaded

**GA-X99-SOC Champion**

\$300

GIGABYTE

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the GA-X99-SOC Champion with a Turbo M.2 port that supports transfers up to 20Gbps from M.2 PCI-E storage devices. You'll also find a SATA Express connector (up to 10Gbps) and 10 6Gbps SATA ports. For external storage, there's also an onboard Thunderbolt header, which can work with an optional GIGABYTE Thunderbolt card to provide 20Gbps Thunderbolt connectivity.

GIGABYTE expects that anyone using this motherboard will be pushing their components hard, so the motherboard is loaded with resilient power-handling components. Digital power controllers from International Rectifier combine with PowIRstage ICs to prevent overheating and improve reliability. The GA-X99-SOC Champion also features chokes and capacitors that can handle high current capacity and deliver maximum efficiency.

Aesthetically, we like the look of the GA-X99-SOC Champion. Similar to the rest of the SOC lineup, GIGABYTE uses an orange and black color scheme that's a nice departure from the red and black

found on so many gaming mainboards. We also like the layout of the VRM heatsinks, which essentially surround the DIMM slots and CPU socket. Conventional layouts typically don't have a VRM heatsink to the right of the memory, which leaves most boards looking a bit unbalanced. The sharp look is complemented by ambient orange LED trace lighting, which marks the separation of the audio PCB from the mainboard components.

If you've been paying attention thus far, it should be no surprise that the GA-X99-SOC Champion easily handled our benchmarks. Some of the more notable scores include 2255.34 pixels per second in POV-Ray 3.7 and 1098 points in Cinebench 15, both processor-intensive tests. In our gaming benchmarks, Metro: Last Light ran at nearly 80fps, and Aliens vs. Predator hit 94.9fps. A 3DMark Professional overall score of 9606 is impressive, too.

At \$300, the GA-X99-SOC Champion is quite a value for overclockers. Rather than providing you with everything plus

Benchmark Results	GIGABYTE GA-X99-SOC Champion
3DMark Professional (Fire Strike Extreme)	9606
Graphics Score	10942
Physics Score	14658
PCMark 8	
Creative Score	5168
SiSoftware Sandra 2015	
Dhrystone AVX2 (GIPS)	241.9
Whetstone AVX (GFLOPS)	120
Multi-Media Integer AVX2 x32 (Mpixels/s)	337.31
Multi-Media Long-int AVX2 x16 (Mpixels/s)	144.3
Multi-Media Quad ALU x1 (Mpixels/s)	2.2
Integer B/F AVX/128 (GBps, mem bandwidth)	23
Floating B/F AVX/128 (GBps, mem bandwidth)	23.13
POV-Ray 3.7 Beta*	2255.34
Cinebench 15**	1098
Games (2,560 x 1,600)	
Metro: Last Light (16XAF)	79.76
Aliens vs. Predator (4XAA, 16XAF)	94.9
* pixels per second	
** points	

the kitchen sink, this motherboard is focused on helping you squeeze every bit of performance you can out of your hardware. That's a design we can get behind. ■

BY NATHAN LAKE

Specs: Max Memory: 32GB DDR4 (DDR4-2133; Max OC: DD4-3400); Slots: 4 PCI-E x16, 3 PCI-E x1; Storage: 10 6Gbps SATA, 1 SATA Express, 1 M.2 (type 2242/2260/2280); Rear I/O: 4 USB 3.0, 4 USB 2.0, 2 PS/2, 1 optical S/PDIF out, audio I/O, 1 Gigabit Ethernet; Form factor: E-ATX; Warranty: 3 years

Test system specs: Processor: Intel Core i7-5820K; GPU: EVGA GeForce GTX 970 SSC ACX 2.0 (2x, SLI); Memory 16GB Crucial Ballistix Sport DDR4-2400; Storage: 240GB Intel SSD 730 Series; OS: Windows 8.1 Enterprise



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Tt eSPORTS VENTUS X

The importance of making the right choice when buying a gaming mouse is often overlooked, and it's fairly easy to see why. Lots of times we prioritize things such as what color the LEDs are or how many buttons a mouse has over one factor that at the end of the day is possibly the most important: comfort. That's not to say the number of buttons isn't relevant, and we'll be the first to admit that given the choice, we'd prefer a mouse that matches the rest of our stuff over one that doesn't.

It's just that your mouse plays a bigger role in reducing fatigue and repetitive stress injuries than just about any other part of your computer setup. It follows, then, that the best mice are those that look good, are highly functional and customizable, and that also feel really good under your hand for extended periods of time.

That leads us to the VENTUS X, the latest in a long line of quality gaming mice from Thermaltake's Tt eSPORTS division. Functionally, the VENTUS X

has everything you need: It has an Avago 5,700dpi laser sensor and adjustable polling rates ranging from 125 to 1,000Hz, and you can very easily get the speed you are most comfortable with, thanks to the small black button behind the scroll wheel. With its included software, VENTUS X lets you create and switch among as many as five gaming profiles, allowing you to create custom button setups and macros for different games or different characters.

Like many modern gaming mice, the VENTUS X also has a long cable sleeved in braided nylon to prevent binding. It has six buttons (including the scroll wheel and the dpi button) that provide plenty of control options without getting in the way.

But where the VENTUS X really shines is in how comfortable it is to use. For starters, the mouse's shape is a classic design that fits perfectly into the hand's natural rest position (assuming you are right-handed, anyway). In addition, its outer shell is a new take on the soft touch finish that you frequently see on mice and

cases lately; it feels soft but it's every bit as durable as hard plastic, and the rubber insets along the sides of the mouse ensure that you won't lose your grip regardless of your play style. Tt eSPORTS also cut a honeycomb-style series of ventilation holes into the VENTUS X's outer shell that helps ameliorate sweaty hands that might cause a loss of grip.

We play-tested this mouse alongside a gaming mouse from another major brand, and the VENTUS X acquitted itself admirably. Not only was it every bit as accurate and functional as its competition (which cost nearly twice as much, by the way), but it also was vastly more comfortable when used for two or more hours at a stretch. Or, as many PC gamers would say, "when used normally." ■

BY CHRIS TRUMBLE

VENTUS X

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Specs: Sensor: 5,700dpi laser; Polling rate: 125 to 1,000Hz; Body type: Right-handed; 6 buttons; 5 profiles; red LED backlight; Weighted: Yes; Interface: USB



Supermicro S5 Mid-Tower

Supermicro is first and foremost a server and workstation company, so you will be forgiven if it's not the first brand name you think of when someone says "DIY PC case." But the S5 mid-tower is a DIY case for ATX and microATX rigs, and it's not even Supermicro's first. A couple years ago, the company launched the 5038AD-T—a case, power supply, and Z87 motherboard combo that was Supermicro's first major foray into the DIY PC gaming market.

Right out of the box it's apparent that Supermicro got some feedback from the last case and paid heed to that feedback, as the S5 has a much more refined interior, a cleaner exterior, and lots of amenities. (The list of the latter includes rubber-grommeted cable management slots on the motherboard tray, tool-less drive trays throughout, knurled thumbscrews for securing the side panels and drive cages, and removable

magnetic dust filters at the top and bottom.)

One improvement in particular for which we applaud Supermicro is the S5's inner configurability. Whereas the interior of the 5038AD-T was somewhat more rigidly compartmented, all of the S5's drive bay cages below the top 5.25-inch bays are modular, meaning that you can stack them however you like or take some or all of them out. This makes it much easier to implement a custom cooling loop, for example, as you can repurpose the space where the drive bay cages are in the S5's standard configuration and use it to mount your pump-reservoir combo.

The S5's exterior is mostly black steel, with a sculpted front panel finished with brushed aluminum inset panels and red plastic trim. The brushed aluminum is a nice touch, and the black grille below the 5.25-inch drives is a plastic grid that you

can push in and easily pop out in the event that you want to remove or replace the twin 120mm intake fans that reside behind the panel. (This is one of two potential 240mm radiator locations; the other is the portion of the bottom panel in front of the power supply mount.)

In short, the Supermicro S5 is an attractive mid-tower with a flexible interior that will accommodate all kinds of PC builds. And even though it's a consumer case, like most Supermicro products it's built tough enough to withstand industrial-type use, which means that it might be the last case you'll need to buy in a long, long time. ■

BY CHRIS TRUMBLE

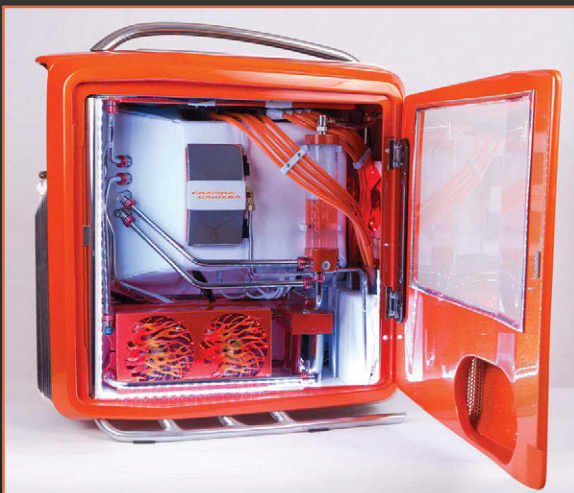
S5 Mid-Tower

Supermicro

www.supermicro.com

Specs: Dimensions: 18.1 x 7.9 x 19.4 inches (HxWxD); Materials: steel, aluminum, plastic; Motherboard support: microATX, ATX; Drive bays: 2 x 5.25-inch external, 6 x 2.5/3.5-inch internal, 4 x 2.5-inch internal; Fans (included): 2 x 120mm LED front, 1 x 120mm rear; Fans (optional): 2 x 120mm bottom; Ports: 2 x USB 3.0, audio I/O

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Cosmos Cruiser

If you've been reading "Mad Reader Mod" long, you are probably aware that occasionally a modder's work is good enough to earn him a repeat performance in the space, and on very rare occasions, some folks have even made the cut three times. This month marks just the second time in the history of "Mad Reader Mod" that our winner has appeared here for the fourth time. For some perspective on this, consider that only one modder, Bill "Mnpctech" Owen, has had more winning mods.

Brian "Boddaker" Carter is well-known among modders and mod fans, and not just because he is a fairly prolific artist. It's also because Carter's work is as close to perfection as we've seen; he sweats the details like nobody else, and when his vision for a mod includes something he can't get off the shelf (and it usually does), he fabricates the custom parts he needs and holds himself to the same exacting standard.

This combination of perfectionism and artistic flair has produced some of the most memorable mods to ever grace these pages, including especially his groundbreaking Battlestar Galactica mod and the iconic TRON Light Cycle mod. But this month's winning mod, the Cosmos Cruiser, represents his best work yet.

Hot Rod

"I have always been a hot-rod enthusiast," Carter says. "I've been building and working on muscle cars since high school, and I learned how to do bodywork and mechanical repairs from my father, who was a lead mechanic at United Airlines for 35 years. After my TRON scratch build, I decided to combine my love for hot rods and computer case modding and do a hot rod-themed case mod. The COSMOS II was the perfect case for this."

Appropriately, Carter does his modding in a space in his garage, although he says a new workshop is in the planning stages and should be complete by summer.

Carter says the Cosmos Cruiser has been a two-and-a-half-year project, although he occasionally stopped work on it to do other projects. He used fiberglass to fabricate most of the panels on the case, and since this was his first project to use fiberglass, he spent quite a bit of time researching the material and its related processes before getting started.

"The top panel and the entire 'engine compartment' side panel is completely made out of fiberglass, along with the side scoops," he says. "The right-side door was skinned in fiberglass, as well."

Bods' Mods

Speaking of the engine compartment, Carter says that it was the main focus of the mod. "I designed it with specific hardware in mind, so everything fits perfectly," Carter says. "This is the main feature that shows off the hardware and custom watercooling. I designed a water channel manifold to accommodate two separate cooling loops (one for the CPU and motherboard blocks, and one for the video cards).

"I gutted the entire case and fused the new fiberglass engine compartment together with the side bezel so it could be mounted back onto the frame," Carter explains. "One of the things I didn't like on the COSMOS II case was the location of the top aluminum handles, so I relocated them to the center of the top panel to give the case a more streamlined look. I custom-fabricated the entire top panel out of fiberglass and incorporated the handles as well as a center mesh panel that allows exhaust for the top 420mm radiator's fans."

Carter also changed the way the COSMOS' side panel opened as an homage to a classic car feature. "A popular mod on the custom hot rods of the 1930s and '40s was to have suicide doors (where they reverse the direction that the doors open so that they open from the front)," he says. "So I relocated the hinges on the right side door from the front to the rear, added a large window to the door for a better view of the internals, and fabricated some custom side scoops to match the lines of the case."



As you can see in the photos, Carter redesigned the entire front panel of the case, as well, in order to add the chrome grille that dominates it. He also custom-built the bezel above the grille that houses the Cosmos Cruiser's 7-inch touchscreen, Lampttron fan controller, USB 3.0 ports, and one final touch.

"Of course I added an ignition key switch that powers the computer on," Carter says.

Of course. If all of this sounds like a lot of work, buckle up—Carter was just getting warmed up. He also didn't like the COSMOS' bottom rails (aka its feet), so he chopped them up and re-welded them together to simulate exhaust headers. He actually had to order more rails from Cooler Master to get all the ends he needed to make this work.

Carter mounted the power supply vertically at the back of the case and ran the ATX and video card power cables through orange tubing to simulate spark plug wires.

"I ran all the other wires through aluminum brake lines, in keeping with the automotive theme," Carter says, and then adds, "I will admit I don't enjoy sleeving cables, and will go to great lengths to find alternate methods of hiding my cables!"

No complaints here.

Carter needed a custom SSD mount, so he built a backlit module to hold the Cruiser's twin drives, complete with chrome covers for each drive. He used 1/2-inch stainless steel tubing to connect all of the liquid-cooling components

and built custom 3D flame grilles for the lower radiator and his back panel exhaust. (He designed them in Adobe Illustrator, had PrimoChill cut them from 1/8-inch acrylic for him, and then used a heat gun to bend each flame lick, intertwining them so that they weave in and out of each other. The finishing touch came in the form of a paint job, compliments of Bob Stewart.)

Next, Carter built a new back panel from scratch out of acrylic, made a flip-up "fuel" door for the fill port at the top of the panel to match the aluminum bars coming down from the top panel, and built a new I/O panel "because the motherboard I/O was nowhere near the rear panel anymore." Carter's not kidding; he rotated the board so that the "rear" of the board—the portion that houses the I/O ports—faces the bottom of the case. So he used extension cables to bridge the gap between the custom panel and the ports on the rear of the board. Oh, and he also relocated the PSU's power plug to the lower-right corner to make it easier to get to.

Then it was time for finishing touches. Carter used white leather upholstery to cover the interior with a little help from his mom, who sewed the orange double-stitching that runs along the floor of the Cruiser and behind the front panel. Then he modded a Razer DeathStalker Ultimate keyboard to match the case by removing the stock wrist rest, painting it orange, and adding the polished aluminum bars that run horizontally along the bottom.

That's A Wrap

Carter would like to thank EVGA, Crucial, Cooler Master, EKWB, Lampttron, Koolance, Razer, and PrimoChill for their contributions to the Cosmos Cruiser.

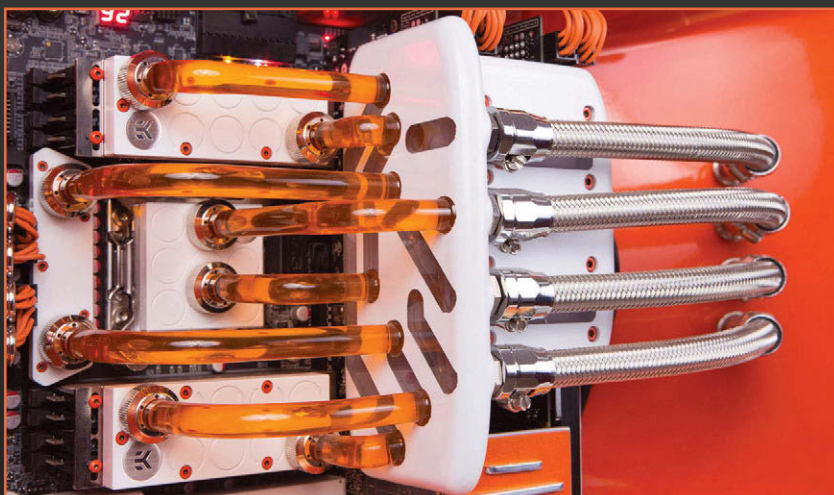
"I'd also like to give a super shout-out to BS Mods for the spectacular show-car-quality paint job, which really elevated this case far beyond my wildest dreams," Carter says. "This is my personal gaming rig, and will be used for years to come."

Carter also let us know that he has dedicated this mod to his mother and father, who both passed away last year.

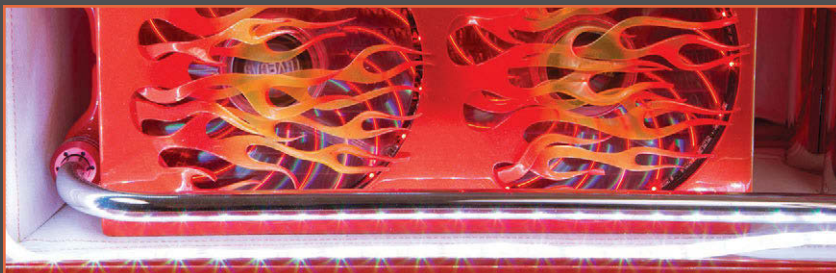
"They worked their entire lives raising us three kids and instilled in me their never-ending devotion and love for our family," Carter says. "My mother was creative, artistic, funny, and always humming a song. My father was mechanically inclined, analytical, stern, and responsible. I'd like to think I inherited some traits from each of them, and I hope I'm making them proud by embracing those traits in each case-modding project I do. Love you, Mom and Dad!" ■



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We Want Your Mod

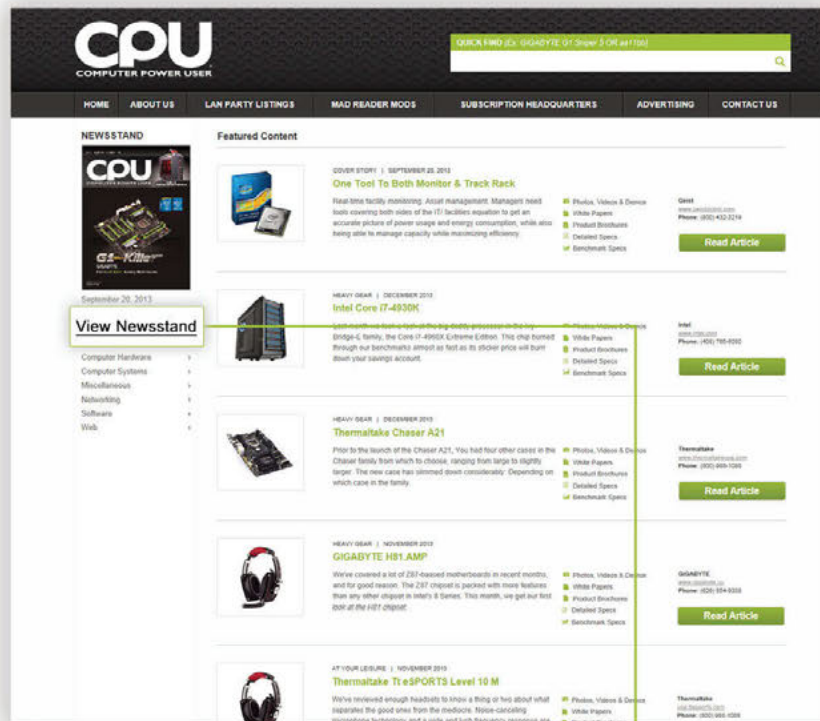
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PDXLAN 25

Portland's Premier LAN Party Is Back

We love LAN parties. The competitive yet congenial trash talking about that epic turn of events in a recent multiplayer match is music to our ears. The flickering glow of monitors and pulse of LEDs through case windows is the perfect mood lighting.

To put your finger on the pulse of modern gamers, just go to a LAN party. Systems on display range from beige box hand-me-downs to meticulously assembled rigs filled with cutting-edge components. Here and there you'll find a jaw-dropping mod that took hundreds of hours to construct. Like few social gatherings can, LANs attract groups of longtime friends, serve as occasional reunions, and have the uncanny knack of making comrades from complete strangers.

Nowhere else is this more true than at PDXLAN. This past February, we attended the PDXLAN 25, an event that boasts 550 seats, in Portland, Ore. During our four-day stay, we conducted a mod contest, signed up new subscribers, talked tech, and got our game on. And yet again, we were reminded why this LAN is so special.



When the lights go down in Portland, let the games begin.

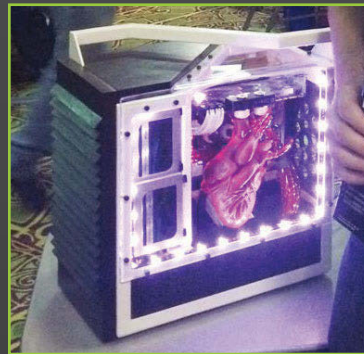
Moddern Marvels

On the second day, *CPU* collected a long list of impressive case mods and spent much of the morning and afternoon agonizing over the candidates to determine which five deserved the honor of making it to the front table. At 6 p.m. that evening, we had PDXLAN 25's top mods on display. As you can see, this event's offerings were some of the most stunning mods we've ever seen.

After much deliberation, we selected Brian "Boddaker" Carter's hotrod-themed Cosmos Cruizer, based on the Cooler Master COSMOS II case. We first laid eyes on this masterpiece at last July's PDXLAN, but Carter went back and finished the system for PDXLAN 25, an event he wasn't initially planning on attending. Needless to say, we're glad he made the trip. For an in-depth look at what made the Cosmos Cruizer the champion of the PDXLAN 25 mod contest, flip to this month's "Mad Reader Mod."

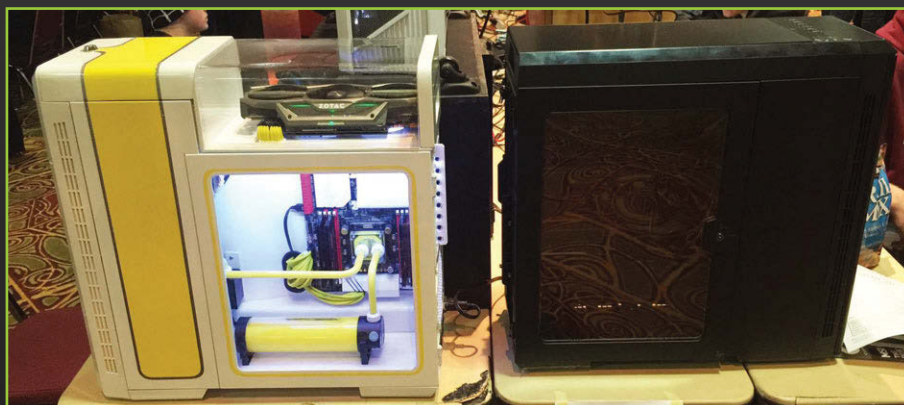


Ron Lee Christianson crafted his spine-tingling "Aliens" mod from a Cooler Master HAF X grafted onto a HAF Stacker 915. He constructed the facehugger, alien eggs, and xenomorph from modelling clay and added numerous details from the "Alien" movies to the exterior and interior of this amazing work of art.



Constructed from solid wood and aluminum tubing, Ben Lzicar's scratch-built beating heart mod actually uses a pump to simulate the beating of the heart.

John Hansz took a Dremel and airbrush, among other tools of the trade, to Thermaltake's Core X9 case to craft his impressive BrimStone mod. The craftsmanship on display here, down to the LED-lit case feet, is truly impressive.



Thermaltake's Urban T81 in its raw form on the right, and what it looks after BSMods (the duo of Rod Rosenberg and Bob Stewart) gets done with it on the left. The truly unique mod shines a spotlight on ZOTAC's GeForce GTX 980 AMP! Edition graphics card.

So Much To See, So Much To Win

Immediately following the mod contest on Saturday night, we held a massive raffle to celebrate PDXLAN's silver jubilee. *CPU* showed up with a pallet-load of prizes to give away. Some of the cases, motherboards, keyboards, mice, and power supplies we handed out to lucky attendees were new; others had suffered the stresses of *CPU*'s benchmarking and testing team; and others still were signed by professional eSports gamers, courtesy of Thermaltake.



PDXLAN is one of the largest LAN parties in the United States.



Those in the market for an upgrade had some pertinent reading material on hand.



Everybody loves winning PC parts!



Lee Harrington's hardline tubing job looks great in white.

Gamers Give Back

Fellowship and gaming are the major reasons people come to PDXLAN, but raising money for charities is right up there, too. At this event, attendees raised \$10,020 buying raffle tickets for a shot at the Mean Green Machine, a system loaded up with cutting-edge parts donated by PDXLAN sponsors and built by a handful of the most skilled modders in the world who were on hand. The money went to benefit the Philip Scholz Memorial Foundation. Over the decade-plus history of PDXLAN, the LAN party has raised more than \$100,000 and donated over 95,000 pounds of food to homeless shelters. Without a doubt, gamers are a generous group.

Once Monday evening rolled around, we had to pack up and head home. Time always flies at PDXLAN, and it was no different at this one. If PDXLAN sounds like an event you'd like to attend, your chance to get there is coming up. Tickets for the 400-seat November PDXLAN go on sale April 19. These shows sell out fast, so sign up early. Until next time, we'll be counting down the days.



The Mean Green Machine charity build raised more than \$10,000 for the Philip Scholz Memorial Foundation.

Some people like flames and skulls on their PCs. Others like rhinestone unicorns. We won't judge.



First and second place winners in the CPU Mod Contest make nice.

cpu[®]

IS MOD CENTRAL

If you love great mods, *CPU* is the place for even more coverage of the latest mods, the greatest modders, and mod contest winners from all over. In these pages, you'll find modified stock cases, custom builds, and everything in between.



And if you have a mod you want to share with the world, drop us a line and let us know at madreadermod@cpumag.com.

Each month, one modder's work will show up on the cover and in the monthly "Mad Reader Mod" feature. If it's yours, you will win a cool \$1,500—and massive bragging rights.

Intel LANFest 2015

LANs Break Out In AZ, NE & MI

As the first quarter of 2015 comes to a close, the Intel LANFest series of LAN parties is in full swing and gearing up for a big summer. In February alone, there were three LANFest events: LANFest DESERTBASH mini-BASH 3, LANFest NETWAR 28.0, and LANFest Gamers For Giving 2015. Read on for a quick recap of each event and a look at some of the PC mods that turned out to strut their stuff.

LANFest DESERTBASH mini-BASH 3

Nestled in the southeastern quadrant of the Phoenix metro, Chandler, Ariz. is home to Intel's Fab 32, a 1 million-square-foot manufacturing facility. On February 7 from 10 a.m. to 8 p.m., Fab 32 was the site of DESERTBASH mini-BASH 3, one in a series of "mini-BASH" events that the LANFest coordinators are holding in the Phoenix area to set the stage for the next full-scale DESERTBASH event, which at press time hadn't been scheduled. A 48-seat BYOC event, mini-BASH 3 included some tournaments, some pizza, and lots and lots of gaming.



Life in the desert can be hard and unforgiving, but the winner of the mini-BASH 3 mod contest knows exactly how to lay low and ride it out. Christian Pantle, one of mini-BASH's excellent volunteer staff, took top honors with his custom rig that is equally at home serving up high-def movies as part of a full home entertainment center as it is playing BioShock, Alan Wake, Dead Space, and the many other excellent games in Pantle's collection.

LANFest NETWAR 28.0

On February 20 and 21, Omaha's premier LAN party took place a few miles away in West Point, Neb. The new venue, West Point's Nielsen Community Center, gave NETWAR organizers room to expand the number of available BYOC seats and turned out to be a great facility. Roomy, modern, and equipped with an excellent grill situated just off of the main hall, NETWAR's new home is located a short drive from both Omaha and Lincoln, and should help the event reach its goals and expand beyond the 300-seat limit from the previous location.



GIGABYTE was in attendance at NETWAR 28.0 and gave away one of its motherboards to the winner of a rock-paper-scissors tournament. A good time was had by all.



NETWAR Mod Contest

This event's mod contest garnered several interesting entries, but in the end it was a close-fought contest between an immaculate small form factor build and the eventual winner, Chris Berger's NZXT Phantom. Berger's interior work includes a full-blown custom cooling subsystem that includes his SLI setup, spot-on lighting, and sleeved cables (Berger sleeved them himself, the old-fashioned way).



In addition to earning him a handsome trophy and a new gaming mouse from Tt eSPORTS, Berger's win makes him eligible for the year-end contest among all LANFest winners for 2015.



Here's a peek inside the runner-up, a Corsair Obsidian 250D mod.



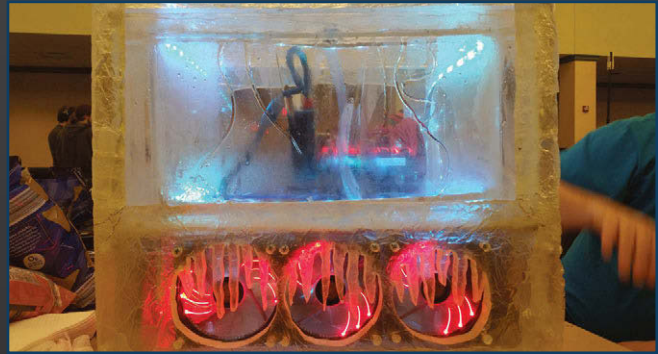
Chris Berger did some nice work on his contest-winning NZXT Phantom mod. His hand-sleeved cables gave him the edge.

LANFest Gamers For Giving 2015

Gamers For Giving, the annual LAN events held through cooperation between Intel LANFest and the Gamers Outreach Foundation, generate charitable donations that the foundation turns into portable gaming carts for kids in hospitals. This year's event took place the same weekend as NETWAR 28.0, and it included (among other things) PC gaming tournaments (League of Legends, CS: GO, StarCraft II: Heart of the Swarm, Call of Duty Advanced Warfare) and console tournaments (a Halo 2: Anniversary tourney, a Super Smash Bros tourney, and the Peggle 2 World Championship).



James Fislar's custom acrylic case (below) looks very, very cold.



Our Gamers For Giving mod contest was a good one, including a new rig from James Fislar, a Mad Reader Mod winner from 2011, and several very nice builds. As we all know, however, there can be only one, and when the dust settled our winner Alex Compton, whose Lunchbox mods combine tight, efficient builds with classic Star Wars imagery and Compton's own graphic twists. Small form factor builds are tough to do well, and sometimes the relief at finding a way to cram all of your components into the case and having them function overrides the compulsion to make the inside look good. But Compton makes excellent use of the limited space and keeps things looking clean and orderly.



DS 200 WINDOW EDITION

- Chassis Dimensions : 210(W) x 527(H) x 485(D)mm
- Super-Silent mid tower gaming case solidly built with 0.8mm steel to block out most of the noise.
- High quality noise insulator on both side panels to further reduce noise.
- Leather coated front and top panels with smooth surface finishing (except standard model).
- Removable 3.5" HDD cage supports long graphic card up to 410mm.
- Supports either 240mm or 280mm water cooling system on both front and top panel.
- Supports max. CPU cooler height of 170mm.
- Supports max. PSU length of 220mm.
- Additional top cover (silence version) included for reducing noise.
- 2xUSB2.0 / 2xUSB3.0 / HD Audio+Mic.

LCD fan controller

Built-in fan controller on top panel:

- * Controls a combined fan power of max. 25Watt with 4 speed settings (stop/low/mid/high).
- * 7 backlight colors selection.
- * Case temperature display (Celsius or Fahrenheit).

Fan controller-7 backlight colors selection



Two types of top covers are included



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GT-RS

- Dual chamber case layout for best cooling efficiency.
- Supports max 5 fans - Dual LED color fan (Blue and Red LEDs) included in the front
- Great Water-cooling Support - either 120 or 240mm radiator
- Supports high-end graphics cards up to 300mm long
- Supports high-end PSU up to 300mm in length
- Fan controller included to adjust the fan speed and change the front fan LED color - can be set to Blue or Red color.
- Unique hard drive mounting rack supports up to 5 HDDs or SSDs
- Dual USB 3.0 Super Speed ports and dual USB 2.0 + HD audio
- Sturdy construction; support up to five fans
- Large Acrylic right side window for clear viewing.
- Left mesh side pane for max cooling.

LED Fan-Switchable to Blue or Red Color



Right side

Left side

Authorized

TigerDirect.com

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State-Of-The-Art Standards

DisplayPort

It's not accurate to call DisplayPort a new specification, after all, it was first ratified in 2006, but given the unexpected persistence of the DVI standard and HDMI's horning in on the computing sector, you could be forgiven for not having made the leap to a DP monitor just yet. With DisplayPort 1.2a-compliant hardware available, gamers finally have a compelling reason to consider an upgrade.

DisplayPort's Roots

Much of what we've seen in display protocols over the past decade or so has revolved around the transition from analog to digital signaling. In 1999, when the DDWG (Digital Display Working Group) released the initial DVI (Digital Visual Interface) specification for connecting a video source to primarily computer displays and projectors, it was built to transmit both signal types. This required cabling and interfaces to feature pins and wires that were dedicated to analog signals and others for the transmission of digital content, as many as 29 signal contacts in total. These design decisions were important for an industry that was in transition, but for today's all-digital all-the-time world, DVI is too bulky, bandwidth-limited, and inefficient.

In May 2006, DisplayPort broke cover as DVI's PC-centric display interface replacement. The organization behind the standard, VESA (the Video Electronics Standards Association), designed it to use a serialized micro-packet transmission technique capable of running over a variable number of



If DisplayPort isn't currently your predominant display connector protocol, it will be in the very near future.

lanes and allocating bandwidth to both audio and video streams on the fly. Architecturally, it's a lot like HDMI, but flexible enough to handle the multiple raw and compressed audio, video, and data transmission formats that are compulsory in computing.

Key aspects of DisplayPort include compact full-sized ports, very small mini ports, high-resolution output, and support for multiple displays from a single connection. The protocol also supports data scrambling, spread spectrum mode, and an embedded self-clock (we'll talk more about this later), which all effectively mitigate electromagnetic interference.

Protocol Revisions

DisplayPort's initial outing was approved by VESA on May 3, 2006, and it had peak data rates up to 8.64Gbps and support for HBR on up to two meter cables. Version 1.1 was approved just less than a year later; it enabled support for alternative link layers such as fiber-optic cabling, but stopped short of actually standardizing the alternative implementations. Because it supports Blu-ray Disc, this version of DisplayPort also added support for HDCP (High-bandwidth Digital Content Protection) and another content protection scheme, called DPCP (DisplayPort Content

Protection). DisplayPort 1.2 came into being on December 22, 2009, delivering support for multiple video streams over a single physical connection and maximum data rates up to 21.6Gbps (called HBR2), as well as support for higher data rates on the auxiliary channel (up to 720Mbps). The 1.2 revision also made way for sources that rely on other color spaces, including xvYCC, sRGB, and Adobe RGB (1998). It added GTC (Global Time Code) for audio synchronization and introduced support for Ethernet, USB 2.0, DPMS, and other types of data to the auxiliary channel's micro-packets. We'll discuss DisplayPort 1.2a later, but it didn't make any bandwidth improvements to the protocol.

DisplayPort 1.3, released in September 2014, features a 32.4Gbps peak data rate that's able to accommodate greater resolution, faster refresh rates, and more color depth than even HDMI. Each lane in the DisplayPort interface supports a variety of component bit depths, including, 6, 8, 10, 12, and 16 bits (up to 48-bit RGB). DisplayPort's



Mini DisplayPort is one of the most compact interfaces in computing.

computer-centric application dictates its reliance on the RGB color model, which divides red, blue, and green into 255 intensities, from very pale (almost white) to the 255th value, which is

fully red, green, and blue. DisplayPort can render Blu-ray's predominant YCbCr color mode at sampling rates of 4:4:4 and 4:2:2, just like HDMI. The first number in the sampling rate refers to the blacks and whites of the image (luminance) and the other two numbers refer to the color sampling rates. Compressed MPEG-2 sources, for instance, have a 4:2:2 sampling rate in which luminance gets more samples than color; this is because it has been demonstrated that the human eye is more sensitive to brightness than to color information. That said, DisplayPort can conform to any required pixel bit depths or colorimetry.

DisplayPort 1.3 has enough effective video bandwidth to support 5K TV displays that run at 5,120 x 2,880 resolutions in RGB mode, and Ultra HD 8K TV displays running at 7,680 x 4,320 resolutions using 4:2:0 subsampling at 60Hz. Regarding computer monitors, version 1.3 supports two Ultra HD (3,840 x 2,160) monitors at 60Hz in 24-bit RGB mode using Coordinated Video



DVI-, VGA-, and HDMI-to-DisplayPort adapters need to be active in order to perform the signal conversion.



This Dual Mode DisplayPort logo identifies the port as being able to use passive adapters.

DisplayPort signals to HDMI, DVI, and VGA-compatible signals, but these conversions will typically require active adapters.

Dual-Mode DisplayPort devices are the exception. With one of these, single-link DVI or HDMI 1.2/1.4 signals can traverse the interface, letting users take advantage of passive adapters that can convert the electrical signaling from LVDS (Low Voltage Differential Signaling) to TMDS (Transition-minimized Differential Signaling). Analog VGA and dual-link DVI sources will still require active adapters, just like all other sources communicating over a standard (non-Dual-Mode) DisplayPort interface.

The protocol is certified to support cable lengths up to 15 meters before you'll need a booster station. For cabling runs greater than 15 meters, DisplayPort can rely on fiber-optic cabling to maintain bandwidth. DisplayPort also has a unique feature that lets it adjust the data transmissions to account for varying signal qualities and cables of varying

Timing, a 4K stereo 3D display, or a 4K display and a powered USB 3.0 data pipe as defined in the DockPort specification (formerly Lightning Bolt). This revision also supports an HDMI compatibility mode that lets it handle HDCP 2.2-secured video and a visually lossless VESA Display Stream Compression algorithm, which results in increased resolutions and color depths while using less power. Prior to March 2015, DisplayPort was a royalty-free protocol, unlike HDMI, but MPEG LA, a patent pool firm supported by Fujitsu, Panasonic, Sony, Mitsubishi, and others recently announced that a license fee of \$0.20 would be applied to each DisplayPort product.

Ports, Cables & Interface

DisplayPort shares more than a passing resemblance to that other all-digital protocol. The interface connector only has one beveled corner instead of HDMI's two and DisplayPort's center post is shaped like a shallow letter U. There are 20 pins for external DisplayPort

connectors, and the connector housing has an optional locking mechanism to help keep them securely in place. Using an adapter, you can convert

DisplayPort 1.3 has enough effective video bandwidth to support 5K TV displays that run at 5,120 × 2,880 resolutions in RGB mode, and Ultra HD 8K TV displays running at 7,680 × 4,320 resolutions using 4:2:0 subsampling at 60Hz.

lengths. For instance, the protocol is rated to support HBR (high bit rate) transmissions over cables up to three meters in length, but copper cabling that is 15 meters and longer will be limited to a 1,920 x 1,080 resolution at 60 frames per second and 24 bits per pixel. These cables are labeled as RBR (reduced bit rate), but they're more affordable and sufficient for use with display devices that are unable to output an image larger than 1080p.

Send Your Video Packing

Packetized data transmission techniques are common in computing specifications, including Ethernet, USB, and PCI Express, but DisplayPort is the first display protocol to take this approach. DisplayPort features an AC-coupled voltage-differential interface, which is similar to the PCI-Express interface. There are three

communication channels used by the protocol: the auxiliary channel (which we already touched on), a hot-plug detection channel, and the main link, where all the magic happens. This link consists of one, two, or four scalable data lanes that can each transmit data at up to 6.48Gbps of effective bandwidth after decoding for up to 25.92Gbps for a 4-lane link. One of the most crippling inefficiencies of DVI is that the protocol requires a separate pair of leads dedicated to transmitting the data clock. DisplayPort's clock, on the other hand, is encoded into the data stream and runs at 162MHz, 270MHz, 540MHz, or 810MHz. With more transmission lines available for raw data, the audio and video fidelity can increase. Additionally, because the packets can contain almost any kind of data, the DisplayPort protocol can accommodate

new features without the need to alter its interface or cables.

Unique Extras

In addition to being able to transmit audio and video from a source device to a display device, a half-duplex auxiliary channel exists to transmit device management and control data in either direction. This channel can transmit data at a rate of 1Mbps or 720Mbps, with the capabilities of the transmitter and receiver and the quality of the cable being the major determining factors.

One such bi-directional data type comes in the form of VESA's EDID (Extended Display Identification Data) which lets the computer or connected device know some details about the display, such as its manufacturer, serial number, product type, phosphor or filter type, refresh rate, display size,



ASUS has a number of G-Sync monitors available that utilize NVIDIA's proprietary variable refresh rate technology.

luminance, and pixel mapping data. Another bonus technology enabled by DisplayPort's bi-directional capability is MCCS (Monitor Command Control Set), also maintained by the VESA. This one is a binary protocol that lets the PC or other device tweak the display's properties, including restoring it to factory presets; adjusting color temperature, hue, and saturation; altering the display's parallelogram and pincushion properties; and adjusting other settings including display orientation, degauss, gamma, zoom, focus, brightness/contrast, backlight control, and more. DPMS (Display Power Management Signaling) is another protocol that hitches a ride on the auxiliary channel to let the system issue various power-centric commands to the display, including switching between normal, standby, suspend, and off modes. VESA also made sure that DisplayPort could carry bi-directional USB signals and even Ethernet data.

Aside from audio and video signals and those mentioned above, DisplayPort can also transmit and carry CEC (Consumer Electronics Control) remote control functions, which refer to a technology that lets you use the remote for one device to perform certain functions on other devices (up to 15) connected via DisplayPort cables. Although it was designed primarily for HDMI and not compatible with native mode DisplayPort, VESA says that these signals can be transmitted over the same half-duplex auxiliary channel used for EDID and MCCS. CEC enables various consumer electronics-centric functions, such as the ability to put your BD player, audio receiver, cable box, and HDTV into standby mode by pressing the power button on the HDTV's remote.

VESA's recent "DisplayPort Alternate Mode on USB Type-C Connector Standard" lets USB Type-C connectors transmit up to four lanes of DisplayPort data,

setting aside one lane for a full USB 3.1 signal, or the DisplayPort AUX channel.

DP 1.2a & Variable Refresh Rates

Although you don't often think about display interfaces on notebooks, the video signal requires a protocol to define how it gets from the GPU and frame buffer under the keyboard to the display's timing controller on the other side of the hinge. Since the mid-nineties, FPD-Link (Flat Panel Display Link) was that protocol, but the electronic characteristics of this link are defined by the LVDS standard. As a physical layer specification, LVDS is a serial protocol that enables high speed communication over twisted-pair copper wires, supporting multiple communication standards for transmitting all manner of data. In 2008, Embedded DisplayPort, or eDP, was introduced to take over for the aging internal FPD-Link protocol. As of last year, AMD and Intel have been actively transitioning away from FPD-Link and LVDS in PC client processors and chipsets in favor of DisplayPort's mobile-centric companion standard.

Ever since its initial launch, eDP has supported seamless refresh rate switching on mobile displays, which acts to reduce the power demands of the system by letting the display refresh only when the frames are ready to be displayed. Because Desktop displays have no such power constraints, synchronizing the display's refresh rate to the speed at which the GPU actually draws frames wasn't considered terribly important. Until fairly recently, your only recourse to solve the visual tearing (where multiple frames are rendered on the screen at once) that results from this asynchronous relationship was to enable a feature called Vsync. While Vsync solves tearing by forcing the GPU to deliver rendered frames in time with the display's refresh rate, it introduces another artifact; stutter, which redraws duplicate frames during those times when the screen needs to refresh, but the GPU hasn't yet delivered the next frame. Incidentally, traditional 60Hz monitors also commonly introduce stutter when playing back the 24 or 25fps (frames



This G-Sync module lets monitors support variable refresh rates when connected to select NVIDIA graphics cards.



Acer is one of the first monitor manufacturers to offer an AMD FreeSync display.

per second) video that is common in movies.

NVIDIA's Kepler- and Maxwell-based GPUs paired with monitors built using a proprietary controller were the first to enable a form of variable refresh rate. Called G-Sync, this feature lets the graphics hardware dictate the refresh rate of compatible monitors, similar to eDP. The result is a tear-free and stutter-proof gaming experience that has to be witnessed to be fully appreciated.

At the 2014 Consumer Electronics Show, AMD demoed a similar variable refresh rate technology running on a notebook, which it calls FreeSync.

Unlike NVIDIA's implementation, FreeSync relied on VESA's eDP and requires no proprietary hardware. VESA made Desktop-based variable refresh rates an official part of the DisplayPort specification, called Adaptive-Sync, or DisplayPort 1.2a. Existing monitors won't be able to support the tech, but they don't require a proprietary controller to operate. Many current graphics cards will also be able to support variable refresh rates, regardless of the name the technology bears, with a simple driver or firmware update. As we went to press, there were several G-Sync monitors available and a few FreeSync

monitors, as well. At CES 2015, AMD's Richard Huddy said there will be at least 20 FreeSync monitors available by the end of the year.

DisplayPort's Time To Shine

It's true, DisplayPort is a superior standard compared to DVI, but it wasn't until the dawn of Adaptive-Sync and DisplayPort 1.2a that enthusiasts had a good reason to consider dumping their old displays for new ones. And with support for enough bandwidth to render 4K, 5K, and up to 8K screens, it's clear that DisplayPort is a protocol that was made for the long haul. ■

GIGABYTE WATERFORCE

Liquid-Cooled 3-Way SLI In-A-Box

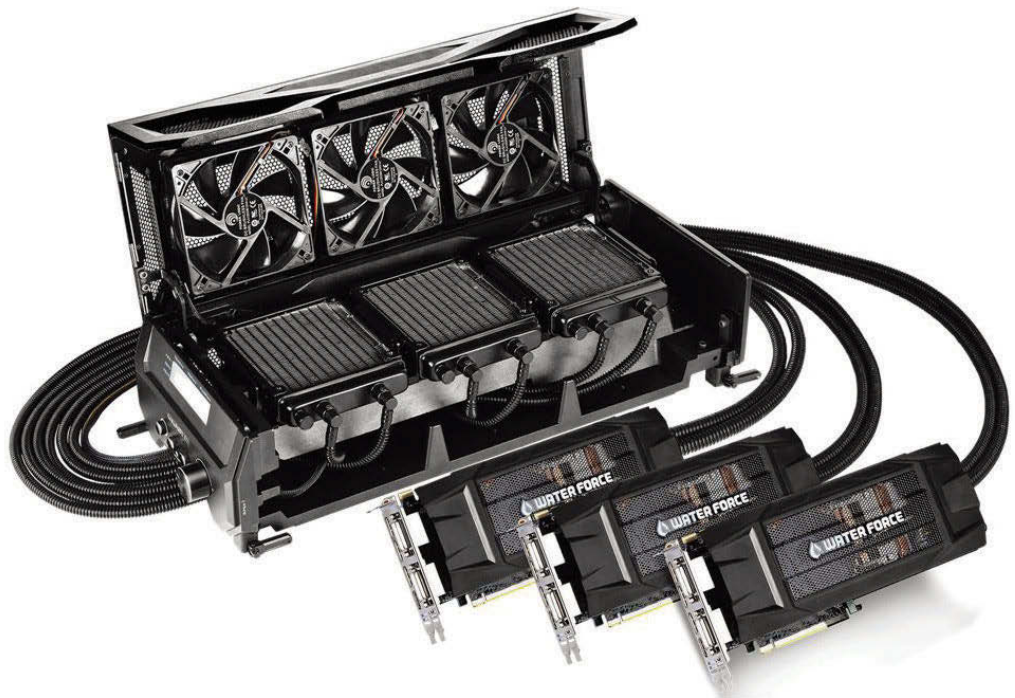
Here at *CPU*, we pride ourselves on the variety of hardware we cover every month. Whether you're a gamer, professional, home theater enthusiast, or just a fan of all things computing, there's something here for just about everyone. The GIGABYTE WATERFORCE, a 3-way SLI watercooling system powered by NVIDIA's GeForce GTX 980, isn't for everyone, but it does offer some nice surprises for deep-pocketed gamers looking for the ultimate gaming upgrade.

What's In The Box?

GIGABYTE's WATERFORCE arrived in its own hard-shell, rolling case that at first seemed like overkill for housing a trio of liquid-cooled GeForce GTX 980s and a spiffy fan controller.

Upon unstrapping and opening the case, however, we found that there's no fluff here. Everything was encased in stiff, molded foam, with graphics cards Nos. 2 and 3 (yes, they're numbered) and each card's closed-loop radiator on the left side of the case. Graphics card No. 1 and its radiator, the large black aluminum watercooling box that will house the rads, the 5.25-inch front panel bay adapter, a unique VGA jack to support each of the graphics cards, a half-dozen pipe clamps, and an LED-backlit SLI bridge were in the right side.

Everything was strapped in place and tightly secured. On top of everything



The GIGABYTE WATERFORCE is an all-in-one, liquid-cooled 3-way SLI kit for beginners. No, seriously.

were installation and troubleshooting guides, plus a fan controller/display panel cheat sheet.

Easier Than You Think

With all the parts laid out and the instructions in hand, installing this system in your PC seems like it'll be a daunting endeavor. Any frankly, it should. Building a standard 3-way SLI or CrossFire setup is no walk in the park, let alone doing it with three liquid-cooled graphics cards connected to a massive external cooling, monitoring, and fan speed control box. But the streamlined installation procedure is where the WATERFORCE truly shines.

Step one involves placing the heavy aluminum box on top of the PC enclosure. The box features a hinged lid that pops up to reveal the numbered radiator bays, and the blue-lit VFD (vacuum fluorescent display) front control panel swings forward to allow the radiator tubes to slide into a routing channel. There are rubber pads on the underside of the box and four spring-loaded clamps that help keep the box stationary once it's in place. The next step is to remove the topmost 5.25-inch drive bay cover and route the bundled data and power cable through that panel. Connect the USB leads on this cable to the motherboard header (this is how the

control panel will receive temperature and fan speed data) and plug the four-pin Molex connector into a spare power port from your power supply.

Once the box and cabling are in place, the next order of business is to install the graphics cards one by one. As you prepare to do this, though, it's imperative to check your motherboard manual to make sure you know in advance which three PCI-E slots to use for 3-way SLI, and no, not just any PEG slot will do. We learned this the hard way; using the wrong three slots negatively impacted performance.

Mind The Gap

Initially, we installed the trio of graphics cards into the top three PCI-E x16 slots of our GIGABYTE GA-X99-Gaming G1 WIFI motherboard, which is the recommended configuration when using Intel's Core i7-5820K processor. We saw decent numbers in every benchmark except Dying Light, which ran at frame rates that



GIGABYTE created this fan speed and temperature control box to house the WATERFORCE's three radiators. It features a hinged lid to allow access to the radiators and a hinged front panel that grants access to the tube routing channel.

Start With A Solid Foundation

Although the GIGABYTE WATERFORCE is a fairly complete package, it assumes you have both a motherboard that can handle 3-way SLI and a power supply that can feed it all. There are a few boxes you'll need to check off before you're ready for the WATERFORCE.

Just because your motherboard has three PCI-E x16 slots doesn't mean you're good to go. The motherboard needs to specifically support 3-way SLI, and each x16 slot must be spaced at least two brackets apart. The number of PCI-E lanes your graphics card has to work with is dictated either by the processor or the chipset. AMD AM3+ chipset-based motherboards get their PCI-E lanes from the chipset. Intel's Z97 and X99 platforms get their PCI-E lanes from the processor. The Intel Core i7-5960X and Core i7-5930K ship with 40 PCI-E lanes enabled, for up to 4-way SLI, and the Core i7-5820K supports 28 PCI-E lanes, for up to 3-way SLI. In this case, either will do. If you're running a Z97 chipset or another mainstream-class motherboard, make sure 3-way SLI is supported; sometimes these motherboards require a PLX chip to boost the number of PCI-E lanes available to feed those graphics cards. The GIGABYTE X99 Gaming G1 WIFI in our system is capable of dedicating a full 16 lanes to two of the three GeForce GTX 980s in the WATERFORCE. In our setup, the middle card ran at x8.

According to GIGABYTE, you'll need at least a 1,200-watt PSU to run the WATERFORCE. If you really want to make sure you're covered, you should add up the TDP (thermal design power) limits of your CPU and graphics cards (the GeForce GTX 980 is a 165-watt graphics card); add 100 watts to cover your fans, hard drives, SSDs, memory, motherboard, and other parts; and allow some extra headroom for any overclocking you plan to do. We like eXtreme Outer Vision's exhaustive eXtreme Power Supply Calculator Lite, which you can use by visiting tinyurl.com/3yk4qu.

The rest of SLI's minimum system requirements include Window 7 32/64-bit or newer and at least 2GB of RAM (4GB for 64-bit OSes). We'd recommend 8GB of RAM at minimum to make sure your system memory doesn't become a bottleneck during gaming.

Last but not least, to get the most out of the WATERFORCE, you'll need a display (or series of displays) that justify the considerable expense. If you have a single 1,920 x 1,080 display, buy two more. A 4K display is another way to get your money's worth out of a setup like this. As you can see from the benchmarks we ran, our 2,560 x 1,600 display wasn't enough to make the rig break a sweat.



There are a handful of unique accessories packed in this kit.



The fan and temperature controls are easy to use and program.

were too close to those we achieved using the 2-way SLI system we benchmarked last month. Back in the motherboard manual, we discovered that our Core i7-5960X requires a gap between the topmost card and the bottom two.

Although this prevented us from using the snazzy LED-lit SLI bridge that came with the WATERFORCE, GIGABYTE's motherboard shipped with the staggered 3-way SLI bridge we required. Sadly, it is devoid of LEDs.

Specs & Scores	GIGABYTE WATERFORCE
Price	\$2,999.99
Core clock	1,228MHz
Boost clock	1,329MHz
Memory clock	1,752MHz
Memory interface	256-bit
Memory	4GB GDDR5
3DMark Professional (Fire Strike Extreme)	15117
Graphics Score	18590
Physics Score	15886
Unigine Heaven 4.0	(1,920 x 1,200)
Score	3323
FPS	131.9
Games	(2,560 x 1,600)
Metro: Last Light (Very High, 16XAF, SSAA off)	85
Aliens vs. Predator (4XAA, 16XAF)	162.3
Dying Light (High)	91.717

Test system specs: Processor: Intel Core i7-5960X; Motherboard: GIGABYTE GA-X99-Gaming G1 WIFI; RAM: 16GB Crucial DDR4-2400; Storage: 240GB OCZ Vertex 3 MAX IOPS SSD; OS: Windows 8 Pro (64-bit)

But as a result of the change-up, our scores improved in every test by between three and 10 frames per second. Our Dying Light frame rate, on the other hand, jumped from the low 70s to the low 90s. This is due to switching from a 3-way SLI setup in which each card runs in x8 mode to one that lets two of the WATERFORCE cards run in x16 mode.

Everything In Its Place

Back to the installation procedure, start with the bottom-most card, plug it into the PCI-E slot indicated by your motherboard

Q&A With Sherri Lee

Graphics cards come and go, and even the best of the best don't deviate much from the tried-and-true designs most manufacturers rely on. Most of these designs have been tested, tweaked, and fussed over for years, so when a company gets it right, there usually isn't a lot of incentive to go back to the drawing board and throw away years of R&D.

With the WATERFORCE, GIGABYTE clearly wasn't afraid to innovate, and it shows. There's nothing shy about this product—it came prepared to make a statement. We sat down with GIGABYTE's Sherri Lee, who explained what goes into making such a groundbreaking, and breathtaking, piece of hardware.

Q The WATERFORCE is such a unique product. Who is GIGABYTE's intended audience for this product?

SL The WATERFORCE is specially designed for the most hardcore gamers, who will settle for nothing less than ultimate graphics performance. To have that much power, we went all out by putting together three NVIDIA GeForce GTX 980 cards in 3-way SLI and have them watercooled in order to reach their full potential. Traditionally DIY watercooling creates a high barrier of entry, with all its complexity in preparation, installation, and maintenance. So, compared to the conventional open-loop watercooling, what WATERFORCE offers is a much friendlier, out-of-the-box 3-way SLI solution, making it more accessible to a wider gaming audience who may not be familiar with DIY watercooling.

Q What were some of the challenges GIGABYTE faced in bringing the WATERFORCE to market?

SL The WATERFORCE is a revolutionary product that has never been seen in the market, so one key challenge that we faced was how to help our intended audience thoroughly realize what WATERFORCE really is and what values and benefits it can offer them. That is the reason why we are working closely with *CPU* to reach out to power users and share our design concept and user benefits. Another challenge was how we had to package this product in order for it to arrive to the users safe and sound. Our HQ explored many options, from metal containers to shrink wrap, when one of our staff members suggested a hard-shell luggage. That is how the GIGABYTE luggage was born!

Q Are there any plans to regularly update the WATERFORCE to support future graphics cards?

SL Right now we are listening closely to our customers and collecting whatever comments and feedback they may have. From there, we could evaluate our next step and bring out something new in the future.

Q What kind of feedback have you received on the product so far?

SL Most people were overwhelmed by its sheer size and what it can do, and they were also particularly impressed with the gaming performance it delivers. The other key feedback we received concerned the pricing of the WATERFORCE. At \$2,999, although this is an expensive product, anyone who looks beyond the price will see that the performance, values, and the innovations our engineers put in more than justify the price.





Each of the GeForce GTX 980s in the WATERFORCE has a pump and waterblock crammed under its shroud.

manual, secure the card in place at the expansion bracket, and add one of the WATERFORCE pipe clamps to roughly the midpoint of the tubing's length. Then, slip the radiator through the 5.25-inch bay and set it aside for now. Repeat these steps to install cards two and three. Next, slip the radiators into the numbered bays in the WATERFORCE box, making sure to tuck the tubes into the channel beneath the front panel of the box as you install each one. Shut the top and front covers. The final steps are to simply slide the 5.25-inch bay box into the open the front panel bay and secure it so that the tubing routes through it neatly. Install the unique VGA jack by manually compressing it to fit it inside the case and adjust the three braces to support each card. Attach the SLI bridge, boot up, install the NVIDIA driver, enable SLI in the NVIDIA Control Panel, and install OC GURU software.

The front panel VFD displays temperatures, fan speeds (in rpm), and

pump speed (also in rpm). There are three buttons that correspond to Mode, Fan Select, and Pump Select, and a large dial that lets you raise or lower speeds and temperature targets. Under load, the temperatures stayed below 50 degrees Celsius, but that's with the fans running at 1,000rpm. You can leave everything at default, which doubles the fan speed when the cards reach 65 C, or input your own temperature targets for each GPU and fan speeds for each radiator. The fans can cycle up to 3,000rpm if your cards run hotter than 75 C (or if your manually set them to run at this speed), but at that speed the WATERFORCE sounds like a jet engine battling with the force of gravity.

To finish configuring the WATERFORCE, use the OC GURU software to find an overclock, perform some benchmarking to determine your desired temperature limits and ideal fan speeds, then just set it and forget it.

All told, installing and configuring the WATERFORCE took us about an hour.

Final Thoughts

The prospect of installing liquid-cooled SLI is intimidating, for good reason—a whole lot can go wrong. GIGABYTE's WATERFORCE makes installation straightforward enough that virtually anyone capable of plugging in a standard air-cooled graphics card can accomplish this, as well. This is a real triumph of engineering, and it's the reason you don't see more products like this available on the market. GIGABYTE had to get very creative, and it's clear that they put a lot of thought into making the WATERFORCE something for anybody to install. If the price tag doesn't scare you away, then this is one of the best ways to get your hands wet with liquid-cooled 3-way SLI (without literally getting your hands wet). ■

3.1 On Board, Baby

MSI Motherboards Deliver The Latest USB Spec

Power users tend to fill up many if not all of the available expansion slots on a motherboard. With little space for add-on cards, a motherboard's onboard I/O connectivity, audio, and networking are critical to optimizing your PC's performance. MSI recently introduced USB 3.1 technology and Type-C connectivity on 10 of its Z97 and X99 motherboards, most all of which already boast impressive built-in audio and networking. "MSI's USB 3.1 is up to two times faster than USB 3.0, allowing speeds up to 10Gbps," says David Chang, channel marketing manager at MSI. "Compared to USB 2.0, it is 20 times faster."

Chang spent some time talking to us about the new lineup and the Z97A GAMING 6 in particular; read on to find out more about this cutting-edge board.

USB 3.1 Advantages

"The ultimate goal with the Z97A GAMING 6, as with any MSI GAMING product, is to further push the boundaries of what quality gaming can be," says Chang. "The Z97A GAMING 6 adds USB 3.1 with a Type-C connector to build upon the previous generation of GAMING motherboard features." MSI powers the USB 3.1 connection with an ASMedia ASM1142 controller. In real-life applications, ASMedia has demonstrated that the ASM1142 can provide 800MBps transfer speeds.

"With USB 3.1, transferring your favorite games, movies, and other media has never been faster or more convenient," says Chang. MSI indicates that you can transfer a Blu-ray movie in less than a minute. To transfer the same movie, a USB 3.0 connection would take nearly two minutes and a USB 2.0 connection would require 20 minutes.



The Z97A GAMING 6 is one of the first motherboards with USB 3.1 onboard.

Plugging devices into the USB 3.1 port will be a no-brainer, because MSI uses a Type-C connector. "Type-C connectivity has all the speed benefits of the Type-A USB 3.1 connector, with one main added benefit—convenience," says Chang. "The Type-C USB 3.1 connector is fully reversible, so there's no more fumbling around trying to get the connector in right side up."

It's easy to tell if a motherboard in the MSI lineup supports USB 3.1, as there's an "A" following the chipset designation in the product name. For example, MSI's X99A XPOWER AC and X99A MPOWER bring USB 3.1 to MSI's yellow and black OC series, while the X99A SLI Krait edition provides USB 3.1 to the black and white series. MSI also introduces the world's first AMD USB 3.1 motherboards via the

990FXA GAMING and 970A SLI Krait Edition.

Game Optimized

Besides the impressive USB 3.1 connectivity, the Z97A GAMING 6 also boasts MSI's Gaming Device Port technology on the rear panel's two USB 2.0 ports and PS/2 port. "The Gaming Device Ports are optimized for high-rate gaming keyboards and mice, and are built to last through thousands of plug inserts and ejects," says Chang. MSI achieves the optimization for high-end peripherals by adding support for 1,000Hz polling to the USB ports and n-key rollover for the PS/2 port. As such, you'll enjoy the fastest response time and the smoothest gameplay possible. MSI also protects these ports from damage that can occur when plugging and unplugging



USB 3.1 is twice as fast as USB 3.0 and 20 times faster than USB 2.0.

peripherals. Chang says “MSI uses triple gold plating on the Gaming Device Ports to ensure extremely long life.”

Professional-Grade Audio

Although it's true that sound quality can be fairly subjective, the collective set of audio hardware and software in the Z97A GAMING 6 is such that you'd have to be using some pretty poor headphones or speakers to dislike your PC's sound. “We brought all the audio hardware you would find on a dedicated sound card and put it onto the motherboard,” says Chang. “A dedicated headphone amplifier, Nichicon gold audio capacitors, and a Hi-Fi amplifier are all onboard the Z97A GAMING 6.”

MSI calls the collective group of additions “Audio Boost 2,” and there's much more to the design than powerful sound-handling components. MSI isolates the audio PCB from the rest of the motherboard. The design ends up being similar to a dedicated sound card, because all of the audio circuitry is buffered to ensure that no electromagnetic interference from

the mainboard will introduce audio distortion. MSI even illuminates the path separating the PCB sections, which adds some cool LED lighting to the motherboard.

MSI is serious about feeding you a clean audio signal. The onboard audio chip, a Realtek ALC1150, boasts a high-grade EMI cover to shield it from electromagnetic interference. MSI also provides you with a Molex-to-3-pin adapter to deliver dedicated power to the Audio Boost 2 components, which should help to consistently drive pure-quality sound. To prevent audio distortion caused by unstable USB voltage, the Z97A GAMING 6 also features MSI's USB Audio Power that delivers a 5V signal to the USB ports.

On the Z97A GAMING 6, MSI provides you with headphone amplifiers for both the front and rear audio outputs. Each amplifier supports studio-quality, 600ohm feeds, so you'll be able to get the most out of a high-end headset—even professional models capable of delivering the highest frequencies and deepest bass. The high-quality Nichicon audio capacitors

help the sound quality, as well, and MSI promises you'll hear exceptional acoustics and realism.

To manage audio playback, MSI includes Creative's Sound Blaster Cinema 2. This software suite lets you customize the sound to your liking. It even features professionally tuned profiles for popular headsets and headphones, so you can maximize sound performance with ease. You can perfect a speaker setup using Sound Blaster Cinema 2's multichannel speaker calibration and configuration tools. Audio Boost 2 supports up to 7.1-channel surround sound, too.

Lag Be Gone

“The Z97A GAMING 6 uses Killer E2205 game networking as its key weapon for killing lag,” says Chang. One of the most compelling features of the E2205 NIC is Killer's Advanced Stream Detect, which analyzes your network and automatically accelerates videogame traffic and real-time game chat software. You'll no longer need to worry about whether background programs, such as updates for Windows



USB 3.1 with reversible
Type C connector

MSI uses a Type-C connector for the USB 3.1 port; the reversible port means you won't ever need to worry about inserting the plug upside down.

and malware definitions, will affect your gameplay. The Killer Network Manager also lets you manually control application traffic. For example, the Visual Bandwidth Control feature lets you see which applications are using the most bandwidth. Based on that information, you can block applications or set bandwidth limits so that

offending programs don't interfere with gaming or multimedia playback.

Broadcast Your Game

With the Z97A GAMING 6, MSI provides you with the software (and license) necessary to mix multiple video and audio streams into your own video game stream, allowing you

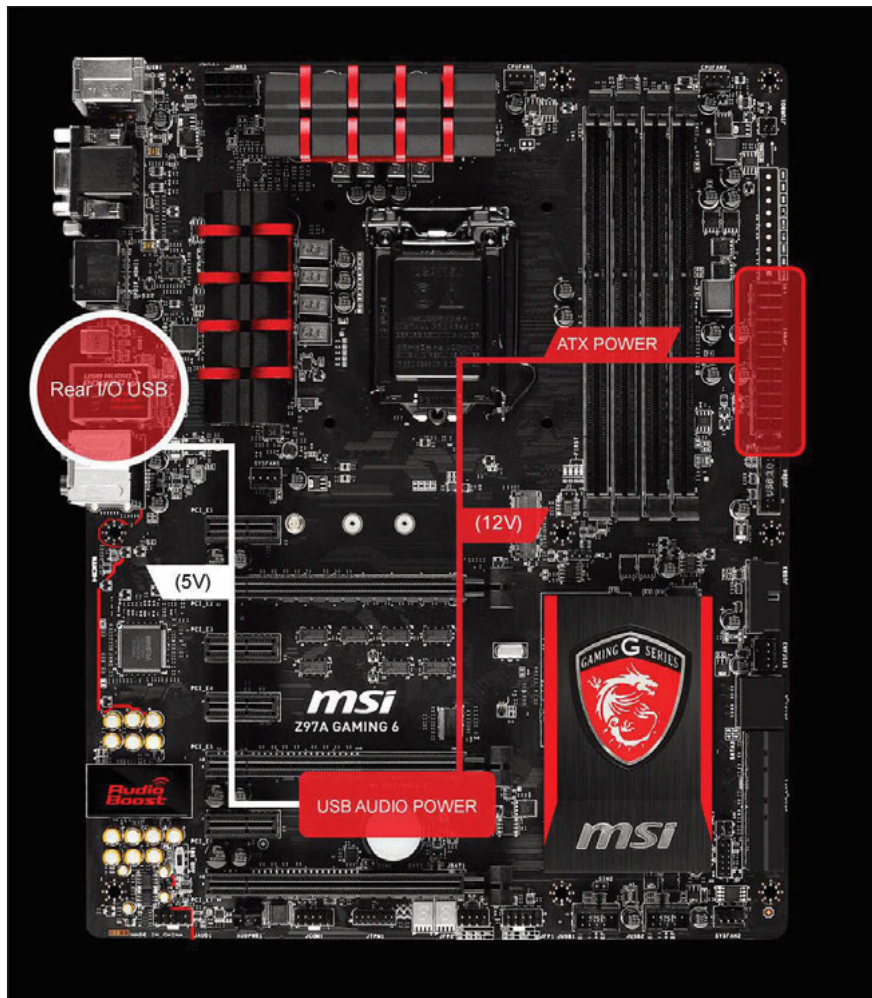
to produce a broadcast that looks and sounds just like the pros. "XSplit Gamecaster is the most popular streaming software on the market, and a six-month premium license is included with the purchase of any MSI GAMING motherboard." XSplit's service also makes it easy to livestream to your favorite gaming websites, including Twitch, HitBot, YouTube, and Dailymotion.

With XSplit Gamecaster, you can arrange the onscreen sources anyway you please. For example, webcam video can be positioned or resized to best fit with your gameplay. "Users can operate Gamecaster via hotkey

to make live streaming available at the touch of a button," says Chang. You can capture the recording for editing later, too. Best of all, XSplit Gamecaster isn't overly complicated, so it doesn't take a broadcasting degree to put together a professional production. XSplit Gamecaster does support some advanced video production elements, though. For



The USB 3.1 port is much smaller than USB 3.0 and USB 2.0 ports. It's closer in size to a Micro-B port than the conventional USB ports.



MSI's USB Audio Power provides a 5V signal to the rear USB ports, which helps prevent audio distortion in USB headsets.

If you prefer to make your overclock alterations in Windows, you can use MSI's Command Center. Chang says "Command Center is a powerful and useful software tool to monitor and fine-tune the system."

The Z97A GAMING 6 also boasts MSI's OC Genie 4 that can automatically overclock the CPU. "OC Genie 4 is a simple push-button feature that will overclock your PC by up to 20%," says Chang. The OC Genie settings can be enabled by a physical button on the motherboard or a virtual button in the BIOS.

For graphics card support, the Z97A GAMING 6 can handle up to 3-way CrossFire or 2-way SLI. In a dual-GPU setup, both graphics cards will run at x8/x8 speed. If you want to use 3-way CrossFire, the cards will run at x8/x4/x4 speed. Besides the three PCI-E x16 3.0 slots, the Z97A GAMING 6 also offers four PCI-E 2.0 x1 slots.

Next-Generation Storage

The MSI Z97A GAMING 6 is equipped to handle the latest in storage technology. There's an M.2 port that supports modules using either the SATA (up to 6Gbps) or PCI-E (up to 10Gbps) interface. You can install M.2 modules 4.2cm, 6cm, or 8cm in length. If you're not ready to move to M.2 just yet, there are also six 6Gbps SATA ports, all of which support RAID 0, 1, 5, and 10 configurations. The onboard SATA ports also work with Intel's Smart Response Technology, Rapid Start Technology, and Smart Connect Technology.

Adopt Early

"The Z97A GAMING 6 is the world's first gaming motherboard equipped with a USB 3.1 Type-C connector," says Chang. If you're the type that's often transferring large collections of personal media or other large files, USB 3.1 will allow you to do so in less time (when connected to a USB 3.1 external storage device). Fortunately, USB 3.1 portable hard drives are starting to hit the market now, so you won't have to wait long to take advantage of the speedy standard. ■

example, you can use the Chroma key feature to superimpose yourself over video (with the help of a green-screen backdrop).

If you want more complex video features, MSI also includes XSplit Broadcaster. This program is geared more toward advanced users who want to create studio-level broadcasts with rich content. For example, you can add remote guests from Skype to the broadcast, as well as 3D composition effects and dynamic text.

Optimize Performance

Superb audio, networking, and connectivity are great, but power users and gamers also require the ability to

optimize a system's big guns. "The Z97A GAMING 6 is a gaming motherboard by design and overclocking can be achieved via several onboard features," says Chang. The mainboard's BIOS allows you to create up to six overclocking profiles, which you can save to the onboard ROM or to a USB drive.

MSI loads the Z97A GAMING 6 with its Click BIOS 4, which is the same BIOS you'll find on MSI's overclocking motherboards. You'll have complete control over the various voltages, frequencies, and clock speeds for the hardware in your system. Impressively, the Z97A GAMING 6 supports DDR3 memory clocked at up to 3,300MHz.

Stick Market Tips

How To Buy System Memory

Power users pride themselves on loading their PCs with flashy components, whether that's a graphics card that flashes its 3D rendering power or a collection of LED fans that literally flash. You can't really build a rig that demands the attention of other enthusiasts without including parts capable of wowing an audience in one way or another. However, plenty of other components may not be as sexy but are nonetheless vital for making a solid system. There are only so many things a manufacturer can do to make an eye-catching power supply, after all.

System memory is another example of a component that (usually) does its job without stealing the spotlight. Yes, manufacturers pride themselves on making enthusiast memory modules with distinct heat spreaders, but performance trumps appearance in this instance; there are better, bolder ways of making a visual statement than a memory kit with slick heat spreaders.

A quality kit of system memory does have its advantages, though. Generally

speaking, a large quantity of fast RAM doesn't become obsolete as quickly as a CPU or graphics card, for example. The form factor of DDR changes at a glacial pace (although as you'll see, this year we're on a collision course for that glacier), so system memory is one of the few components that you can typically transfer from build to build.

Whether you're building a brand-new system or upgrading your current machine, you can't forget about the memory. With our buying advice, you should wind up with the best kit for the cash you have.

DDR4: Dawn Of The DRAM

So about that glacier. The thing about colossal mountains of ice is that they take their sweet time getting from point A to point B, but when they do they have a habit of completely changing the landscape. The latest JEDEC (Joint Electron Device Engineering Council) DRAM DDR standard, DDR4, has

been almost 10 years in the making. And although DDR4 modules have technically arrived on Intel's high-end X99 platform, they have yet to trickle down to the mainstream market. Anyone interested in arming their system with one of Intel's Haswell-E CPUs will have to use DDR4 by default, but a close examination of the new memory standard is helpful for everyone else, as well; we'll all be using DDR4 eventually.

As you'd expect, DDR4 offers quite a few benefits over DDR3. For starters, the new memory is considerably denser than its predecessor, letting manufacturers introduce modules at capacities DDR3 can only imagine. Single memory sticks totaling 128GB (or, theoretically, even more) are the stuff of dreams for IT admins interested in beefing up their servers' memory capacity without bulking up their physical footprint, but such an insanely large module is of limited use to a power user, unless that power user is building his own



It took long enough to get here, but DDR4 is poised to take over your motherboard's DIMM slots. The latest DRAM standard is an improvement over DDR3 in almost every way, offering denser modules, a higher performance ceiling, and lower operating voltage. Although it's currently only supported on one desktop platform, Intel's Haswell-E/X99, DDR4 should reach mainstream hardware later this year.

server. In practical terms, 16GB and 32GB memory modules are a more likely outcome in the desktop segment, which is still a big step up from DDR3 modules that have topped out at 8GB. In short, if you're an enthusiast who feels hamstrung by the amount of DDR3 you can cram into your system, DDR4 is here to save the day.

The second noteworthy engineering feat baked into DDR4 is decreased supply voltage. Just like DDR3 required less voltage than DDR2, DDR4 brings that figure down even further. For example, most DDR3 modules relied on a supply voltage of 1.5V, with DDR3L and DDR3U using 1.35V and 1.25V, respectively. DDR4 modules start at 1.2 volts, a number that will go even lower if low-voltage and ultra-low-voltage DDR4 standards are approved.

We saved the best change for last. In addition to increased module density and decreased voltage, DDR4 will eventually surpass DDR3 in terms of raw speed (but not latency, mind you). DDR3 has effectively peaked at around 3,100MHz. (And truthfully, "3,100MHz" is a misnomer, as the number actually refers to 3,100 megatransfers per second, or MTps, rather than megahertz, but we'll explain that distinction later.) Modules of DDR4 start at DDR4-2133, twice that of the DDR3-1066 modules that were common when DDR3 launched. A couple of manufacturers have already released DDR4-3400 kits, and the speed gap will only widen as DDR4 matures.

With all the improvements DDR4 makes over DDR3, you'd think your buying decision would be a no-brainer. And it is, to an extent: As we mentioned, if you want to hitch a ride on the DDR4 Express, the X99 platform is your only ticket. So, what does this mean if you have system builder bucks burning a hole in your pocket?

Your Current DDR4 Gatekeeper: Haswell-E

Before you jump into a DDR4 setup with both feet, be sure you know what

you're jumping into. The X99 platform has a specific set of requirements, some of which may put DDR4 out of the reach of some buyers. The most prohibitive factor will likely be the CPU, as there are currently only three CPUs that include a DDR4 memory controller. At the time of this writing, Intel's Core i7-5960X (\$1,059), Core i7-5930K (\$594), or Core i7-5820K (\$396) are your choices; in other words, you need to set aside at least \$400 for a processor capable of doing the DDR4 dance.

The other big investment you'll make building a DDR4 system is the memory itself.

Like the last couple of Intel's high-end desktop processor families, Haswell-E CPUs use a quad-channel memory controller. To achieve the best possible system performance, you'll need to buy memory modules in multiples of four. The majority of 16GB (4 x 4GB) kits on the market today are priced between \$200 and \$300, certainly a non-negligible sum. Add the cost of an X99 motherboard (generally speaking, these are also more expensive than their Z97 or 990FX counterparts), a good graphics card or two, adequate solid-state and magnetic storage, plus a reliable power supply and respectable case, and your bill will be well north of \$1,000.

Thankfully, the X99 platform doesn't introduce any other new form factors/standards, so upgraders can hang onto their current graphics card(s), storage drives, and power supply in order keep costs at a minimum.

Anyone in dire need of a better system who doesn't have the funds to sink into a Haswell-E system faces a tricky



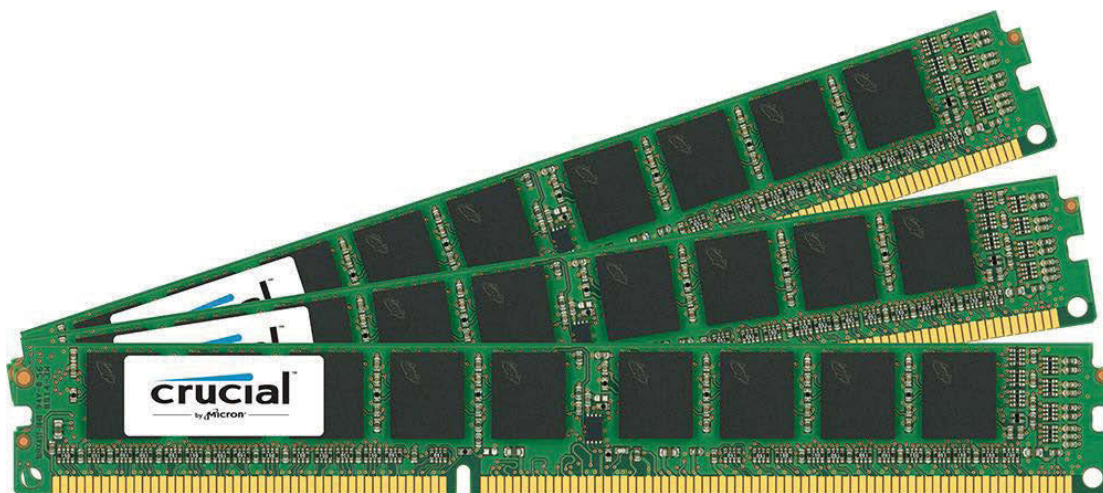
So you want to use DDR4 in your next system build? Great choice, but be aware that there are only three desktop processors with the necessary memory controller: Intel's Core i7-5960X, Core i7-5930K, and Core i7-5820K.

proposition: Save money by upgrading to a more affordable platform but risk buying system memory that in all likelihood will be incompatible with future platforms. DDR3 has enjoyed a long and fruitful life, but that life is coming to an end. High-end, high-speed DDR3 kits are still available for purchase, of course, but the next time you upgrade your components, you won't be bringing that kit with you.

You'll rarely find us recommending that you don't buy the best hardware you can afford, but if you're going to acquire new components for a system that uses DDR3, our advice at the moment is to stick with the sticks you have, if possible. If capacity is the concern, try to supplement, not replace, your existing DDR3. Eventually, you will be moving to DDR4, and that move should be as painless on your wallet as possible.

The Exception: UniDIMM

Users who lean on their laptops to do most of their heavy lifting will catch a



ECC (error-correcting code) memory, which has built-in circuitry that's capable of identifying and fixing DRAM errors, sounds like a great thing. After all, who wouldn't want their memory to do this? As it turns out, there really isn't a compelling reason for desktop users—even power users—to buy ECC memory. This type of memory is useful in servers and certain specialized computing, such as scientific research and financial analysis, but it's not terribly beneficial for desktop applications.

break. In order to ease the transition from DDR3 to DDR4, Intel has spearheaded the development of UniDIMM (Universal DIMM) memory modules to coincide with the upcoming launch of the company's Skylake platform. Unlike most platforms, Skylake's memory controller will be able to address DDR3 or DDR4, so consumers will be able to buy Skylake-based laptops with DDR3 when they arrive and then upgrade to DDR4 UniDIMMs down the road. It's a nice solution, considering system memory is one of the most frequently upgraded laptop components.

Despite the advantage of seamlessly transitioning from DDR3 to DDR4, the UniDIMM form factor isn't without its own complications. Although they share the same physical dimensions as standard DDR4 SO-DIMMs, UniDIMM modules won't be pin-compatible with standard DDR4 SO-DIMMs. Therefore, laptops with UniDIMM slots must use UniDIMM sticks, which is another type of lock-in. For anyone planning to buy a laptop this year, keep this information in mind and keep a close eye on product spec sheets.

Megahertz, Megatransfers, Latency & You

If there's one thing power users like as much as getting PC hardware, it's arguing about PC hardware. On any given forum you'll find champions of this or that company, or this or that technology, engaging in polite discourse about matters near and dear to their hearts. It comes with the territory.

One such discussion that's a Google search away is memory speed vs. timings, aka the "tastes great vs. less filling" debate for DDR. The kindergarten version of memory speed vs. timings (the latter of which is a module's latency) is that as memory speed (the number of bits it can transfer per clock cycle) increases, so too does its latency.

Before further exploring the relationship between speed and latency, we should explain how a memory module's speed is frequently misrepresented. Take a kit of DDR3-2133, which many people will tell you has an operating frequency of 2,133MHz. That's inaccurate. This memory kit's bus frequency is 1,066MHz, or 1,066 megatransfers per second. However, DDR (double data rate—get it?) is

able to transfer data on both the rising and falling edge of its reference clock, doubling the modules' bandwidth to 2,133MTps, hence DDR3-2133.

We'll keep our imaginary kit of DDR3-2133 around to illustrate the relationship between MTps and latency, and we'll add another kit of DDR3-1866 to the mix. Let's assume that the kits of DDR3-1866 and DDR3-2133 have CAS latencies of 9 and 11, respectively. CAS latency refers to the number of clock cycles it takes the memory to respond to a data request, so our DDR3-1866 kit requires nine clock cycles to achieve its rated bandwidth of 1,866MTps. The DDR3-2133 kit can deliver 2,133MTps but requires 11 clock cycles to do so. In certain circumstances, memory with lower MTps and low (or "tight") timings could end up with a higher bandwidth overall than memory that offers superior MTps at the expense of looser timings.

However, DRAM has evolved to the point that high-speed memory winds up outpacing low-latency memory. We put this notion to the test in the August 2014 issue of CPU. (See "Memory Matters" on page 61.) Starting with a kit of DDR3-2800,

we tested a few combinations of speeds and latency and ultimately determined performance was better when we sacrificed latency for higher MTps.

And in some regards, the argument is moot. The industry as a whole has trended toward using faster and faster RAM with looser and looser timings, and enthusiasts haven't seemed to mind.

The question becomes more interesting when you compare two kits of the same speed with different timings. In the abstract, the kit with tighter timings will offer better performance, but that extra performance comes with a price, literally. Between two kits that are identical with the exception of their timings, the kit with tighter timings typically costs \$10 to \$20 more.

Is paying for lower latency worth it? For the majority of system tasks (truly, anything that doesn't lean heavily on a system's memory), the performance difference is so imperceptible that the only way to tell the kits apart is by benchmarking them. And even at that, you'll likely need to use a memory-specific benchmark to tell them apart. If your budget is tight, feel free to cut your kit's timings some slack.

Make No Mistake

Aside from clock speed and latencies, another key feature of DRAM is whether a particular memory module supports ECC (error-correcting code). Memory modules designed for desktop use don't have the necessary circuitry to detect and correct data errors/corruption, which is why they're often referred to as non-ECC memory when distinguishing the two types of memory.

Power users work tirelessly to keep their data safe. It's the reason we have RAID 1 setups, disk cloning tools, backup HDDs, and backup HDDs for those HDDs. At first glance, memory with the built-in ability to identify and fix errors seems like an obvious choice, but memory errors aren't as lethal for desktop users as a failing hard drive, for example. Even in the event non-ECC memory does suffer an error, the odds

are extremely low it will adversely affect you. To wit, we've never encountered an enthusiast who's claimed a DRAM error ruined his life.

Of course, DRAM errors can ruin lives under the right circumstances. When it comes to important scientific research and high-end financial computing, for instance, an error of any kind is absolutely intolerable. And enterprise servers that hum along 24/7 also benefit from ECC memory. Put simply, unless you're a scientist, engineer, financial analyst, or IT admin, buying ECC memory isn't necessary.

Not convinced? Another reason you don't see many power users rocking ECC memory is that manufacturers don't design the modules with enthusiasts in mind. The people who use ECC memory favor reliability above everything else, so releasing ECC memory with colossal heat spreaders and high clock speeds simply isn't a priority for manufacturers. Because of this, the most "extreme" kit of ECC memory modules might have plain, basic heat spreaders at best. Clock speeds on these kits conform to JEDEC specifications in nearly every case, as well. ECC modules are essentially business in the front, and business in the back.

If this still isn't enough to dissuade you from buying ECC memory, we can at least give you a few pointers. Compatibility is critical with ECC memory, as you must surround ECC modules with hardware that supports them. As a general rule, desktop processors' integrated memory controllers don't work with ECC memory, so that will steer you to a workstation CPU by default. Also double-check that your motherboard will support ECC modules, which isn't a given. At the end of the day, to make ECC work its magic, the hardware you'll have to buy will leave your system looking a lot like a workstation, which is kind of the point.

How Much Memory Do I Need?

Calculating the maximum amount of RAM to install in a system was easy in the era of 32-bit hardware and

software. The 32-bit edition of Windows 7 could only address a maximum of 4GB of memory, and a portion of that was reserved for the installed hardware. Anything beyond 4GB was an unnecessary expense.

Obviously, 64-bit software upended that game board. Although certain Win7 x64 users still need to be mindful of the memory limits Microsoft imposes on the OS (64-bit versions of Win7 Home Basic and Home Premium max out at 8GB and 16GB, respectively), Win7 Pro, Enterprise, and Ultimate users can install up to 192GB of memory. Win8 x64 users get an even better deal: The 64-bit standard version of Win8 "limits" you to 128GB, while Win8 Pro x64 lets you go hog wild and install up to 512GB. Although a few desktop motherboards will support 128GB of RAM, you'll need a workstation or server motherboard to go beyond that. Seeing as how we've established that such lofty amounts of RAM are excessive for all but a small subset of power users, the important takeaway is that modern operating systems and hardware shouldn't put a ceiling on that amount of RAM you can install.

This brings us back to the question at hand: How much memory does a power user need? As much as we'd like to avoid giving the following answer, it depends. A gamer who has built a PC to be nothing more than a killer gaming rig clearly doesn't need as much RAM as a content creator who likes to spend her time working with complicated Photoshop files or editing 4K video. Even saying, "I only use this system to search the web for funny cat photos" is full of variables. How many tabs do you normally keep open in your cat photo hunt? Do you use a lot of extensions that enhance your consumption of those funny cat photos? These things use RAM. Everything a PC does uses RAM.

Starting with the operating system, Win8 x64 is designed to be more lightweight than its predecessor, but you'll still need at least 2GB to start the party.

Those two gigabytes of RAM will also be enough to handle a basic productivity suite such as Office 2013 x64, and none of the major browsers ask for more than that, either. Naturally, though, even using two relatively simple programs in concert can quickly eat up your system memory as you open multiple documents and tabs, run extensions, and so forth. As a result, even the PC you build from spare parts so your kids have something to use for homework, Netflix, and Minecraft should have at least 4GB of RAM at its disposal. Anything less is asking for trouble.

Minecraft itself is excellent proof that games have developed quite an appetite for system memory, as well. It's not

Crysis by any measure, but developer Mojang recommends at least 4GB of RAM before you play in Minecraft's sandbox. Games that push PCs to their limit are even more demanding. Take recent AAA titles like *Evolve* and *Dying Light*, which recommend 6GB and 8GB of RAM, respectively (and *Dying Light*'s initial recommended specs called for a whopping 16GB). Considering that this is par for the course nowadays, gamers and other enthusiasts should really consider 8GB of RAM as the ground floor for a new system build or an upgrade. If you want to futureproof your system, 16GB is a smart investment. Just remember

that any DDR3 you buy will be left behind whenever you upgrade to a CPU/motherboard combination that requires DDR4.

Seasoned content creators already have a good understanding of the vast amount of system memory needed to ply their craft. Prosumers hoping to become professionals—whether that's photography, videography, or, to a lesser extent, audio production—must be prepared to fill up their motherboard's DIMM slots with high-density modules. There is, after all, a good reason Adobe slyly indicates that the maximum amount of RAM Photoshop x64 can use is “as much as you can fit in your computer.”



Conventional wisdom said that massive amounts of DRAM were only necessary for programs that were notorious memory hogs, such as Adobe Photoshop. Throw that wisdom out the window. Videogames, for example, have grown considerably hungrier for memory over the last few years. “Simple” games such as Minecraft require 4GB for optimal performance, and the original recommended specs for the recently released *Dying Light* called for 16GB of memory.

Programs like Photoshop, After Effects, and the like utilize massive amounts of memory as the changes you make to a file increase the program's History and Cache.

Similarly, although working with HD and 4K video is commonly considered a CPU-intensive task, it can require quite a lot of RAM, too, especially if you're also using your video-editing software side by side with image-editing software. For serious image or video editing (no, cropping a photobomber out of a shot or adding music to your home videos doesn't count), we'd recommend starting with 16GB, but 32GB or more may be necessary as your projects become more complicated.

Cash For Kits

You'll want to thoroughly examine potential memory kits before making a final decision, as there are thousands of kits on the market today. A comprehensive review of that market in this article is futile, so we found the biggest brush we could to paint in broad strokes, because even making

generalizations about DRAM pricing can be tricky.

The trouble with making generalizations is that even statements like "DDR4 is more expensive than DDR3" have easy-to-find exceptions. At press time, for instance, a sampling of quad-channel (4 x 4GB) DDR3-2400 kits ranged from \$154.99 to \$299.99, while DDR4 of the same speed and quantity cost between \$154.99 and \$315.97; the overlap is obvious.

Clumsy as it may be, we've taken a three-tiered, "good, better, best" approach to give you a snapshot of the system memory market. For DDR3, we looked at the following three groups of 8GB (2 x 4GB) dual-channel kits: DDR3-1600, DDR3-2400, and DDR3-3000. The DDR3-1600 and DDR3-2400 kits were reasonably priced, with the majority of kits priced between \$50 and \$75 and \$75 and \$100, respectively. The price for wicked-fast DDR3 skyrockets, though, as none of the four kits we found cost less than \$395.

For DDR4, we checked prices on the following three sets of 16GB (4 x 4GB) quad-channel kits: DDR4-2133, DDR4-2800, and DDR4-3200. At DDR4-2133, almost all of the kits we found were priced between \$199.99 and \$259.99. Kits of DDR4-2800 were more expensive, but not outrageously so: The bulk of the kits cost between \$249.99 and \$299.99. Like DDR3, the price of DDR4 really shoots up at the highest speeds. None of the five kits of DDR4-3200 we found cost less than \$399.99, and a tricked-out kit with clamp-on active cooling was a budget-busting \$669.99. DDR4-3300 and DDR4-3333 kits are even more expensive.

The bottom line is that system memory isn't any different from other PC components where pricing is concerned. Builders on a budget can still buy a respectable amount of memory without taking out a second mortgage, while anyone who insists on the best of the best should be prepared to raid their treasury to buy the kit of their dreams. Frankly, the mind-boggling number of memory kits means buyers can get exactly what they want at a price they can handle. This is the way buying PC parts should work.

All Together Now

Up to this point, we've equipped you with the know-how to buy all the major components for your first, next, or even current build. Next month comes the fun part: actually building. Few things are as satisfying as spending a weekend surrounded with quality components and plenty of time to assemble them to our liking. You're responsible for your own drinks and snacks, but the tips and tricks are on us. ■



Of course, some stereotypes are just as applicable now as they ever were. If you want to make the most out of the 64-bit version of Adobe Photoshop, you should earmark extra money in your budget to buy more RAM. You might be able to squeak by with 16GB of memory, but if you're serious about editing images or video, 32GB or even 64GB of system memory is a solid investment.

Lithium-Ion Leadership

SolidEnergy Aims To Build A Better Battery

Those keynote speeches and live events certainly make it seem like Big Device Company's latest RadPhone is truly the most revolutionary RadPhone yet. (Previous RadPhone were just "sort of revolutionary.") All at once, the new RadPhone has a much faster processor; bigger, brighter, and denser screen; and built-in image sensor that puts the D-SLR you just bought last week to shame. The bad news is that your current RadPhone is now an obsolete paperweight, but the good news is that a super-friendly clerk at a Big Device Store near you has a brand-new RadPhone with your name on it!

So you gleefully line up at Big Device Store the day of launch so you can be one of the first to get the new RadPhone. Finally, it's yours, and it's everything the enthusiastic man in jeans on the stage said it would be. Well, almost everything. Despite all of the advancements in RadPhone technology, one constant is that its lithium-ion rechargeable battery never seems to last as long after a few months of use.

For mobile users who frequently spend hours on end away from any means of recharging their devices, the problem of Li-ion batteries steadily declining in potency is a vexing one indeed. The market has recognized this, too, with no shortage of companies jockeying to sell you their portable fuel cell, which will keep all of your mobile stuff chugging along even when there's no wall outlet or cigarette lighter in sight.

These portable "bonus batteries" make practical sense, but at the same time they run counter to a key ethos of the smartphone: more functions, fewer devices. It's been years since we've had



Believe it or not, although smartphones have advanced by leaps and bounds, the technology behind the batteries that power them has remained relatively stagnant over the last 25 years. Massachusetts-based startup SolidEnergy Systems is developing new materials for use in Li-ion batteries that the company claims will double battery life.

to carry around a watch, digital music player, digital camera, and a cell phone. Putting more things, a portable fuel cell in this instance, back in your pocket is a step in the wrong direction.

There's another solution staring everyone in the face. Instead of making extra batteries, why not simply make a better battery? This is the notion driving SolidEnergy Systems, a small startup located on the outskirts of Boston

in Waltham, Mass. The company is working on a groundbreaking new design that promises batteries that hold twice as much of a charge as existing mobile devices. Although still in the prototype phase, SolidEnergy's work could make the next RadPhone even radder.

Born At MIT

SolidEnergy can trace its beginnings a few miles down the road from its

current headquarters. In 2012, founder and CEO Qichao Hu established the company while working on his doctoral and postdoctoral work at the Massachusetts Institute of Technology. With the guidance of Professor Donald Sadoway, who serves as SolidEnergy's Chief Science Advisor, Hu founded SolidEnergy along with Lei Peng and Louis Beryl.

By SolidEnergy's own admission, the company doesn't want to be pegged as a battery builder. In a promotional video, SolidEnergy states, "We intend to make materials, not batteries," with the idea that companies with existing battery fabrication infrastructure will be able to incorporate SolidEnergy's materials into existing processes, making it much easier to create new, long-lasting batteries.

SolidEnergy caught a break by partnering with another nearby company,

A123 Systems. According to the *Boston Business Journal*, SolidEnergy struck an agreement with A123 to use the latter's manufacturing capabilities to produce the batteries. As a result, SolidEnergy was able to develop a prototype in record time. Instead of the normal three-to-five-year development cycle similar companies require to create a prototype, SolidEnergy needed a mere 12 months.

The ambition that drove SolidEnergy so quickly from concept to prototype is helping the company reach the market with tangible products as early as next year. SolidEnergy's goal is to work with its partners to release a battery for smartphones and wearables in 2016. The year after, SolidEnergy has set its sights on the electric car market, hoping to introduce a battery that the company claims will double the driving range of existing EV batteries.

Electro-Shenanigans

It's hard to believe that battery technology has changed little over the last two and a half decades, but making the right mix of materials so a battery can hold a longer charge without bursting into flames is a tricky proposition. Traditionally, battery makers have relied on graphite as the battery's electrode. Lithium is a superior electrode, but prior to SolidEnergy's innovations the metal was difficult to incorporate into batteries. When lithium comes in contact with a battery cell's electrolyte, the resulting chemical reaction creates compounds that trap the lithium ions and prevent them from producing an electrical current. Gradually over time, this reduces a battery's capacity. Another reaction that results from lithium interacting with the electrolyte



It should come as no surprise that the ideas and research that led to the formation of SolidEnergy Systems were developed at the Massachusetts Institute of Technology. While still a doctoral candidate at MIT (and with help from Professor Donald Sadoway), SolidEnergy founder and CEO Qichao Hu established the company along with its two other co-founders, Lei Peng and Louis Beryl.

is the formation of dendrites, which can introduce short circuits that set the electrolyte on fire.

The other option is to use a solid electrolyte in place of a liquid electrolyte. Using a solid electrolyte is advantageous for a couple of reasons: The material is less reactive, and it also stops short circuits from happening. On the other hand, batteries based on solid electrolytes aren't as effective as their counterparts that use liquid electrolytes because the former doesn't conduct ions as well.

SolidEnergy's novel approach relies on both liquid and solid electrolytes, according to the *MIT Technology Review*. Using an extremely thin piece of lithium-metal foil, SolidEnergy then applies a solid electrolyte. Because the lithium sheet is so thin, it cuts down on the distance ions need to travel, which is typically a drawback of using a solid electrolyte. The ions pass through the solid electrolyte to reach a liquid electrolyte; SolidEnergy's liquid electrolyte is not flammable and contains additives that inhibit the formation of dendrites.

(Almost) No Anode Necessary

Another basic battery design is using an anode and cathode. In an electrolytic cell, electrons flow from the anode to the cathode. Traditional rechargeable batteries found in cell phones and similar devices typically rely on a carbon or silicon-composite anode, but SolidEnergy found that both of these designs have energy densities that leave something to be desired. For example, a common carbon anode battery offers an energy density of 600Wh/L, according to SolidEnergy, while a battery that has a silicon-based anode is a little better, at 800Wh/L.

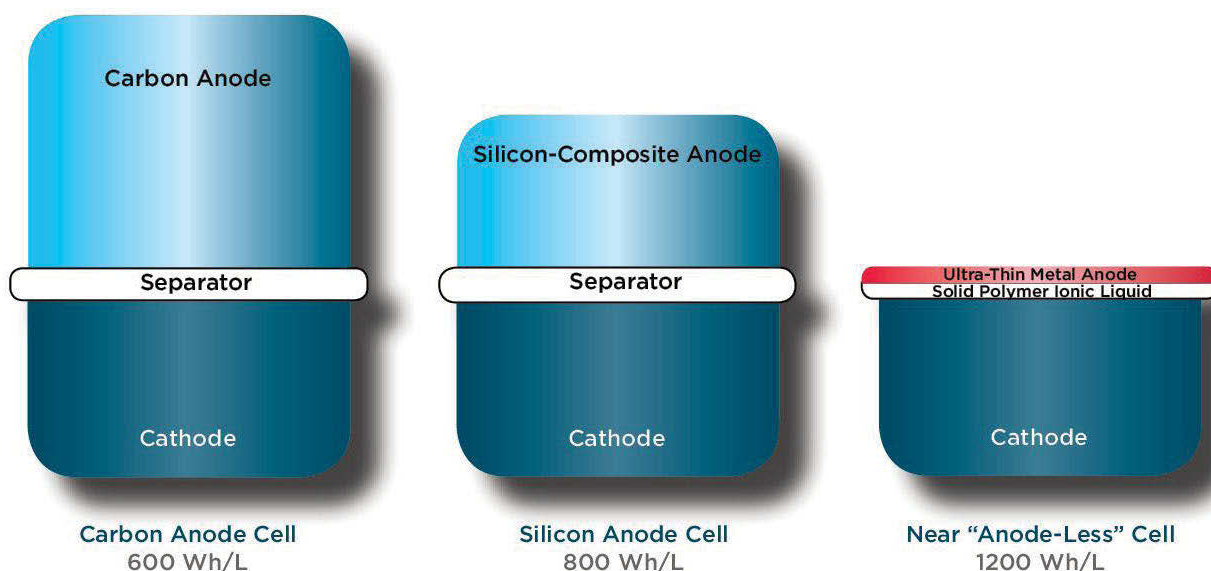
SolidEnergy's "ultra-thin metal anode" combines with a solid polymer ionic liquid to produce a battery cell with an energy density of 1,200Wh/L. By reducing their battery's anode to a fraction of the size of traditional batteries, SolidEnergy is able to produce much smaller batteries than what mobile devices use today. According to the *MIT Technology Review*, SolidEnergy's prototype can be recharged up to 300 times and still hang on to 80% of its original charge. If the company's new

battery truly does offer twice as much charge as today's batteries, it could easily be a viable replacement as soon as SolidEnergy releases it to market.

The Next Steps

Like a lot of startups, SolidEnergy Systems remains a relatively small company, employing around a dozen people at the time of this writing. According to the *Boston Business Journal*, SolidEnergy's first infusion of cash came in the form of \$4.5 million in Series A funding spearheaded by the Singapore-based investment firm Temasek Holdings. Hu is seeking an additional \$10 million in Series B funding this year, and SolidEnergy is already putting its IP to work in endeavors like Google's Project Ara.

SolidEnergy's current goal is to create the materials necessary to release 30 million of its super batteries for cell phones by next year. If the company makes good on this, and it also follows through on incorporating its technology in electric car batteries, SolidEnergy could become the next big name in batteries. ■



One of the key innovations behind SolidEnergy Systems' battery tech is the use of a cell that is almost completely free of a traditional anode.



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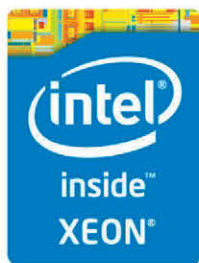
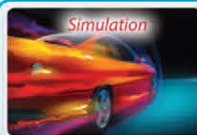
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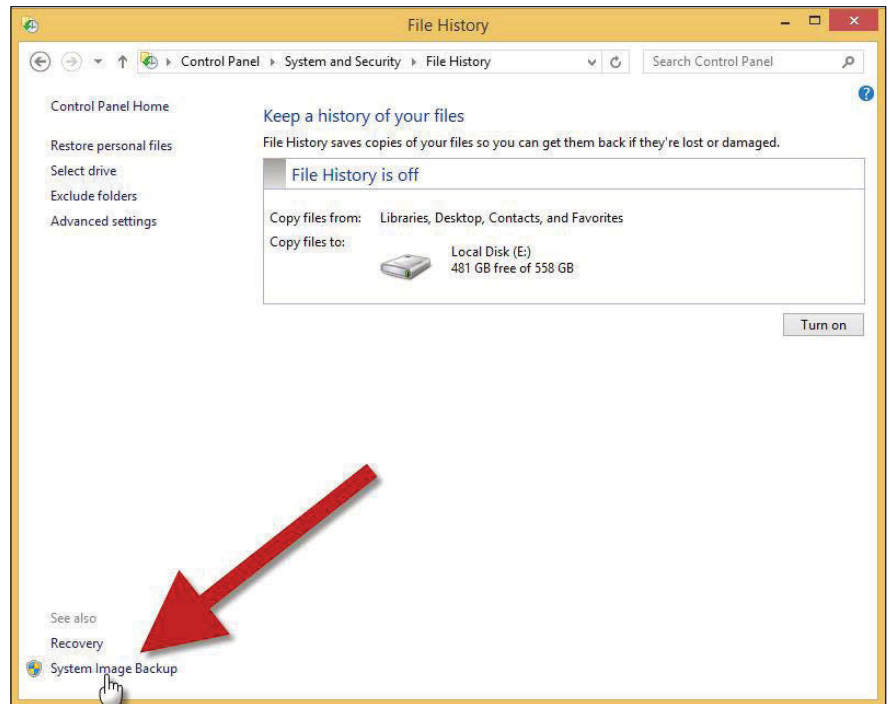
Backup & Cloning In Windows 8.1

Nothing beats a clone. Being able to create an exact copy of a drive is useful for backing up data, applications, and settings as a precaution against drive failure or as a means to upgrade from an existing drive to a new one. As the name suggests, a cloned drive looks and runs exactly the same as the drive on which it was based. After swapping the drives, the rest of your hardware is none the wiser. Using a system image is the fastest way to recover from a software, hard drive, or SSD failure, and it's a favorite troubleshooting option for IT professionals, PC builders, and enthusiasts alike.

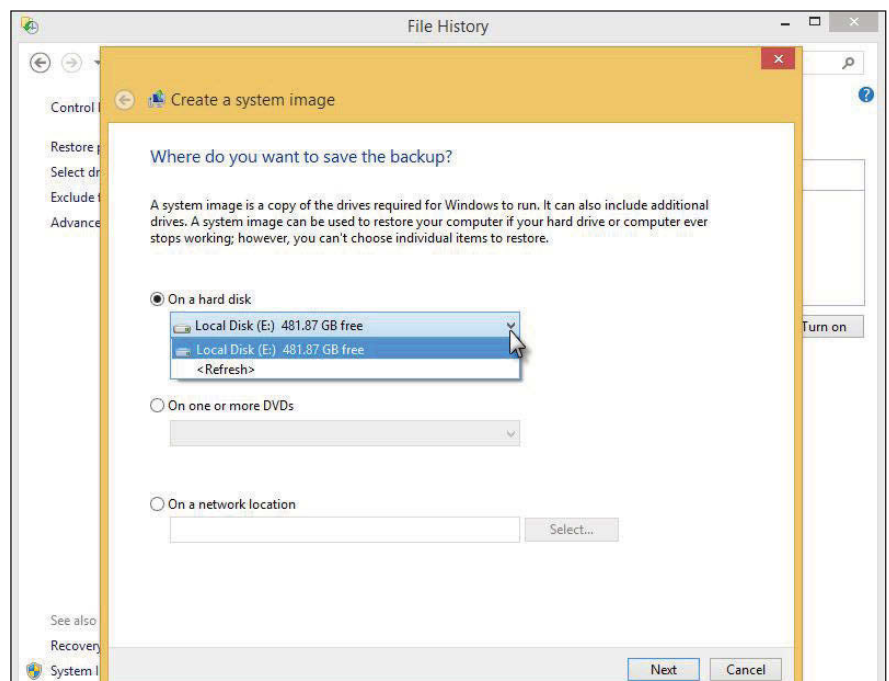
Where In the World Is Windows 8.1's Cloning Utility?

The need for a built-in cloning utility in Windows is not lost on Microsoft; backup and cloning are standard features in Windows 7. To launch the system imaging utility, all you have to do is search using the term "back up" or open the Control Panel and navigate to System And Security and then Backup And Restore, and then just click Create A System Image in the left side of the window. All in all, it's a fairly intuitive process.

In Windows 8.1, however, Microsoft has inexplicably nixed the Backup And Restore subcategory in the Control Panel. If you search using the term "back up," you will get two options, Back Up PC Settings and File History Settings. The former feature lets you merely sync settings to One Drive, which covers things like Start screen tile layouts, background images, themes, Windows Store apps you've installed, browser favorites, and a handful of other things. The Windows 8.1 File History Settings feature doesn't let you create system images, either; it's designed to take snapshots of individual files to keep a log of the changes you've



Windows 8.1's System Image Backup utility is not very easy to find.



The first step in the process of creating a system image is to select the destination.

made. If you ever lose a document, music file, image, video file, Desktop folder, or offline One Drive file, this

feature will let you recover it at virtually any stage. Although File History can be useful, it won't do you much good

if you're looking to upgrade your OS drive, for instance.

But don't leave Windows 8.1's File History Control Panel page just yet. This is where you'll find the rather out-of-the-way System Image Backup utility, under the See Also heading in the lower-left corner of the page. Click the hyperlink to launch it.

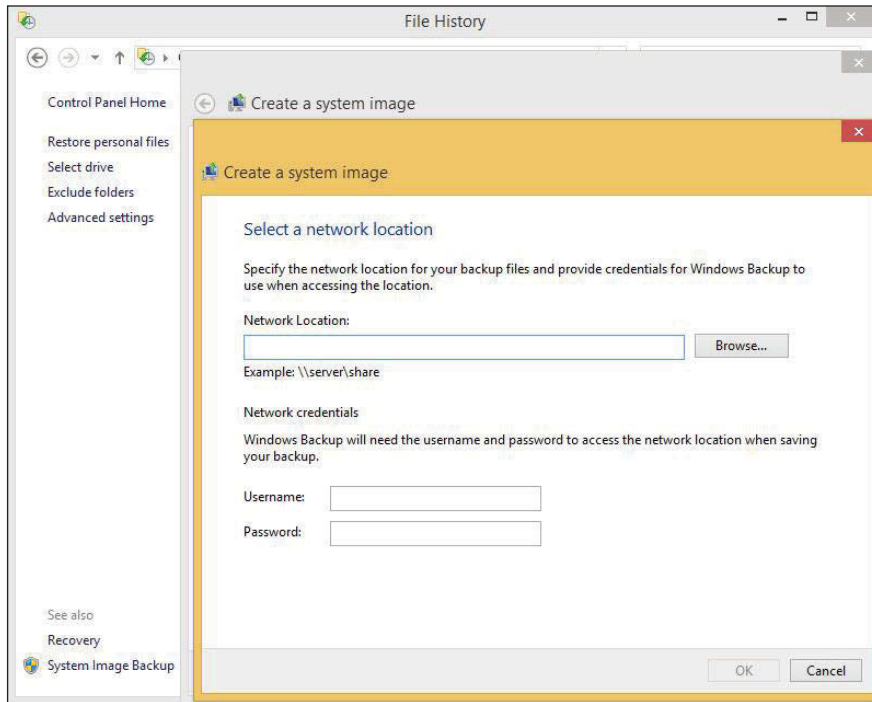
Create An Image

Immediately upon clicking the System Image Backup hyperlink, the Create A System Image wizard launches and scans your system for backup devices, such as auxiliary storage drives (other than your C:\ root drive); blank recordable CDs, DVDs, or Blu-ray Discs; or network targets. The first step of the process involves choosing the location where your system image will be stored. If neither of the first two are detected, the utility will default to the third option, On A Network Location.

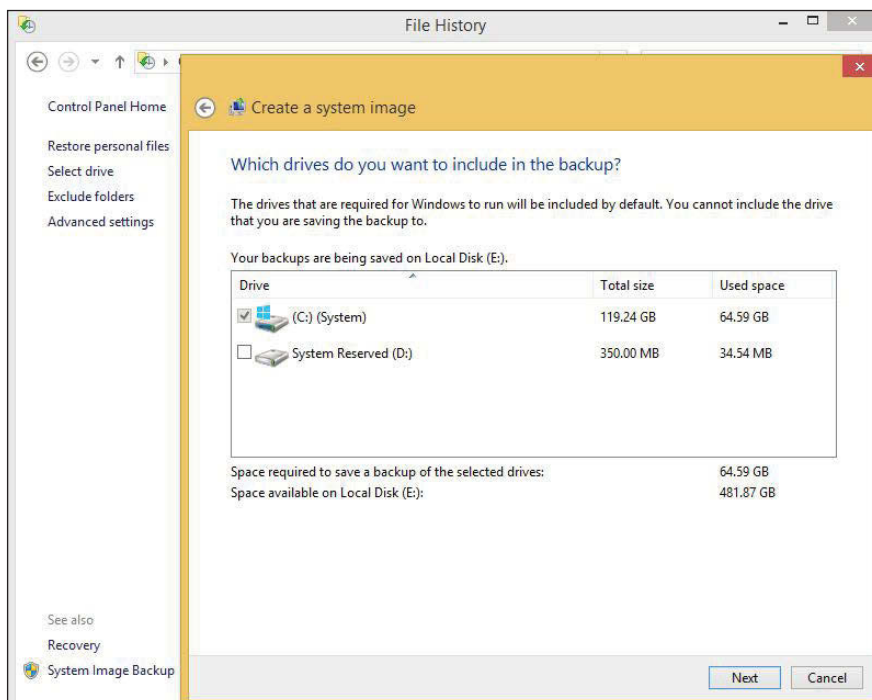
If you don't see the option you want, try adding media to your optical drive or plugging in an external storage device, click the radio button for your desired category, click the drop-down icon, and click Refresh to rescan for devices. If you choose a network location, you'll see a message warning that backed up data cannot be securely protected for network targets. Hard disk locations (and SSDs) will need to be formatted with NTFS to be viable options.

When you have a location selected, click Next to proceed. Now that you have a destination for the system image, it's time to select a source. The utility lists drives by name and letter; just click the checkboxes next to the source(s) you want to include in the image. As you may discover, you can't choose a source that exists on your destination drive. Click Next to move on.

The Confirm Your Backup Settings screen displays your chosen destination, source location, and the total size of the image file. Click the Start Backup



You can save system images to a network location, but make sure to provide your credentials if they are required.



Select the source, then click Next to move on.

button to begin the process. Our 65GB OS drive image took less than 10 minutes, but the time it takes to create your image will depend on the read/write speeds of the source and destination storage devices, as well as the amount of data to be cloned. If you have created a system image on this destination, it may be overwritten with this new image. When the backup has been completed, just click Close to dismiss the dialog box.

Create A Recovery Drive

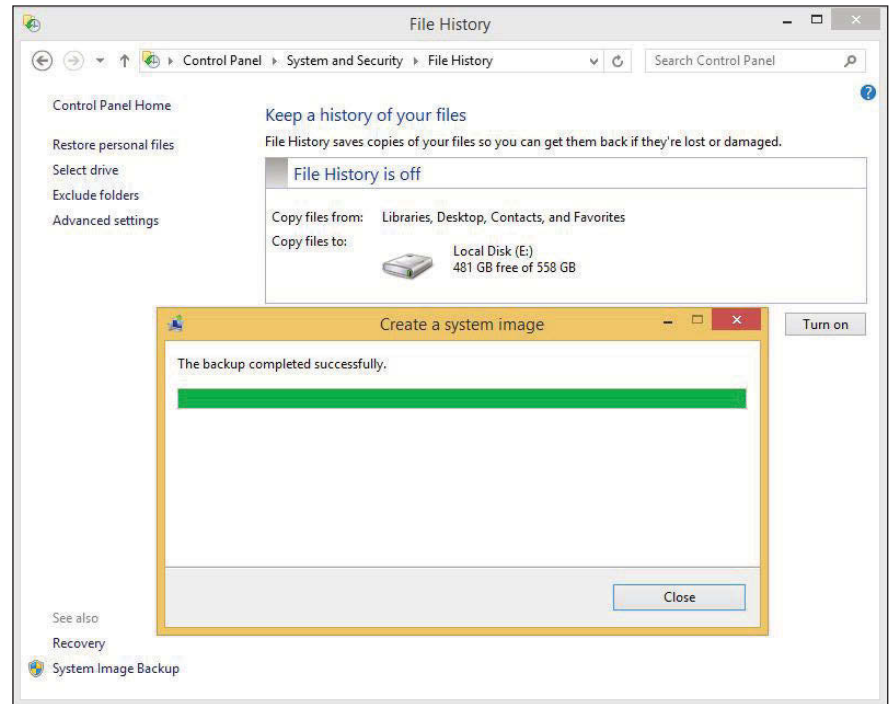
If you followed the procedures described above, then you've already taken the most important steps in protecting yourself in the event of a catastrophic drive failure. But if you need to recover your system using the image you just created, there's another tool you'll need to get the job done. It's called a recovery drive, and although you can create one using any working PC with Windows 8.1 on it, you can save yourself some time by making one right now while your PC is running just fine.

System images can't be launched from within Windows because the utility requires root access to the OS drive to perform the rewriting. This tool will let you boot your PC into a special recovery environment so you can tell the otherwise unresponsive system where your drive image exists and begin the recovery process. Note that your Windows 8.1 installation discs or an existing System Repair Disc will also work as recovery media, so this step would be redundant if you have either of those handy. If your system features a recovery partition, you can simply boot to this and skip the recovery media creation step altogether.

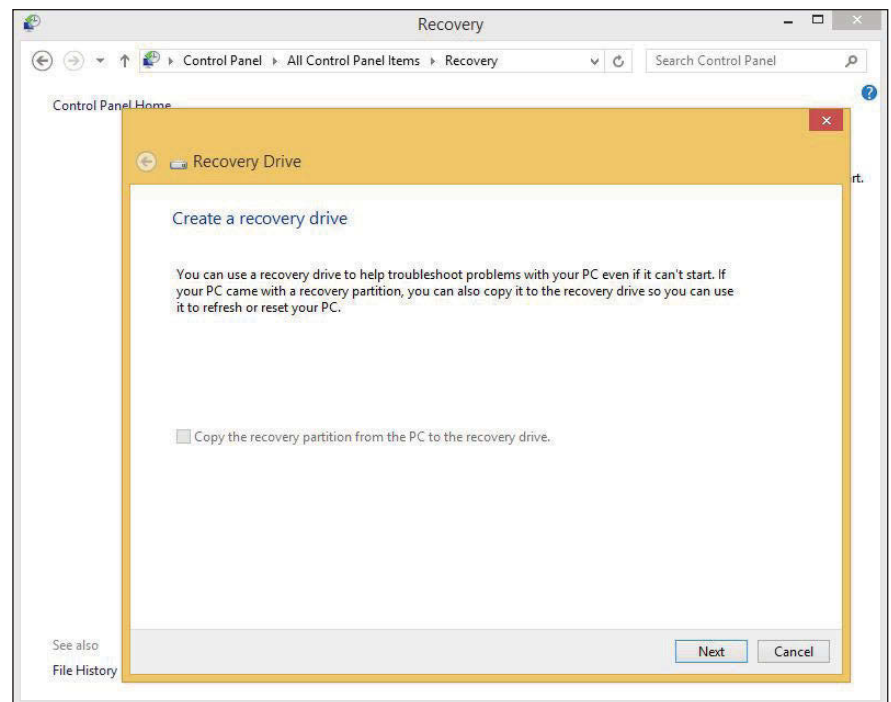
If you don't have a recovery partition, or existing media, you'll need to create it. To launch Windows' Recovery Media Creator, open the Control Panel, click the View By drop-down menu and select either Large or Small Icons to display all Control

Panel items. Next, click Recovery, then click the Create A Recovery Drive hyperlink to launch the utility.

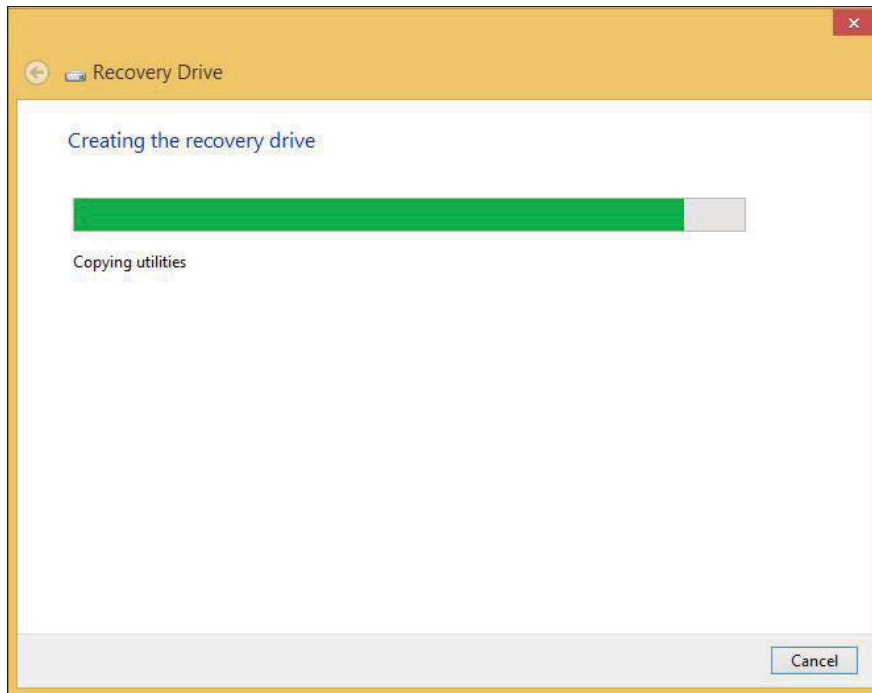
Click Yes if you see a User Account Control message to continue. On the first screen, you'll have the option to



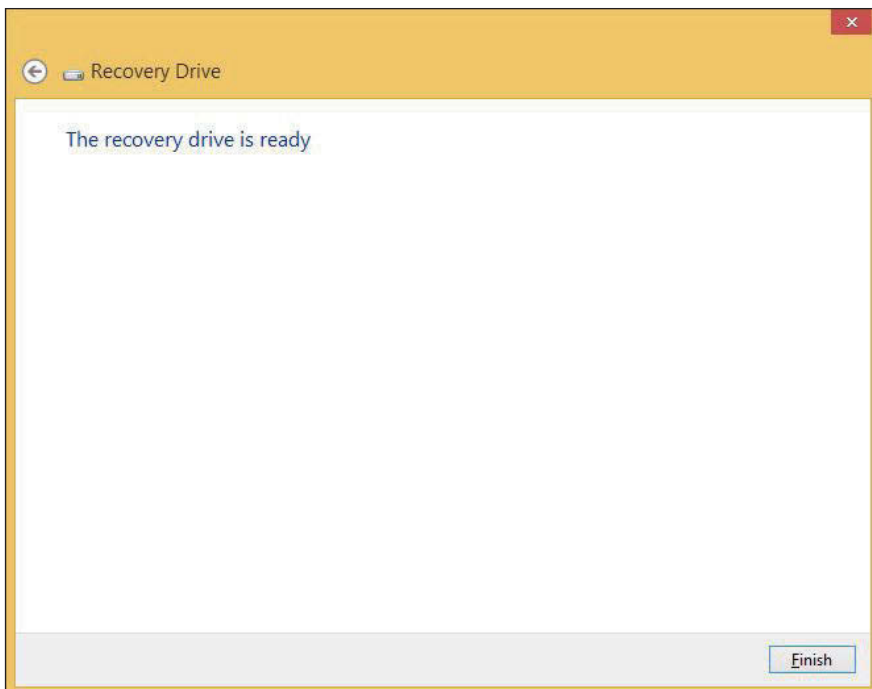
In short order, your system image is saved and you can click Close to complete the task.



The recovery drive is one of several ways you can access an otherwise unbootable computer to restore a system image.



Creating a recovery drive is quick and painless.



Click Finish to close the Recovery Media Creator utility.

Before clicking Next, find a USB thumb drive that's 512MB in capacity or larger. When completed, our drive had 270MB of data written to it. Any data on the USB thumb drive will be overwritten, so make sure you're willing to accept this (or dump the files someplace safe if not), insert the drive into a spare USB port on your system, and then click Next. After a brief scan, the utility should detect and display the USB drive you want to turn into recovery media. Click Next, and the utility starts by formatting the drive, then spends less than a minute copying the files needed to let your system boot from it. When the process is complete, click Finish to close the Recovery Media Creator.

Recovery Time

When you're ready to perform the system recovery, make sure the hardware is connected properly, which includes the hard drive or SSD with the partition to which you want the image written as well as the hard drive or SSD with the partition that houses the image files (they cannot be the same). Next, with the system powered off, plug the USB thumb drive with the recovery media on it into an available USB port on the system. (If using the Windows 8.1 installation disc, insert it now.)

Next, turn the system on, and access the BIOS Setup Menu by pressing the DELETE, F1, or the particular key your system requires (consult your documentation if the boot screen does not tell you which key to press). Next, change the boot device order so that the USB drive is the first on the list (or the optical drive for those using an installation disc; upon reboot, the system will prompt you to press a key to boot from the CD or DVD). When the boot order is properly configured, save your settings, exit, and your system will restart.

The first thing you'll see is the keyboard layout selection screen. Click US to get to the main menu.

copy the recovery partition data to the recovery drive if you have one. If your system came from an OEM, you may have better results doing this to

create viable recovery media. If the option is greyed out, you'll need to have the system create recovery media from scratch.

From the next screen, click Troubleshoot, then click the Advanced Options item from the following screen. Refreshing and Resetting your PC are other options available from the Recovery Media, but like we mentioned at the outset, nothing beats recovering from an image (as long as the problems you're encountering aren't also present in the system image you created). Next, click System Image Recovery to launch the appropriate utility.

If there is more than one OS image available, you may need to select the OS version you're trying to recover. On the Re-image Your Computer wizard's first screen, you can let the utility choose the most recent image it can find (the top radio button), or click the bottom radio button to Select A System Image yourself. Click Next, click the Format And Repartition Disks checkbox. If there are partitions on the destination drive that you don't want formatted and replaced, you can keep them intact using the Exclude Disks button. Click Next to continue to the summary screen. Clicking Finish launches the image recovery process (after you click Yes to process one more warning pop-up).

When the recovery process completes, jump back into the BIOS Setup Menu and make your fresh HDD or SSD the first boot device, then save changes and exit to reboot the system. In the vast majority of instances, this is how you solve virtually any catastrophic software or storage device failure. ■

REGISTRY EDIT OF THE MONTH:

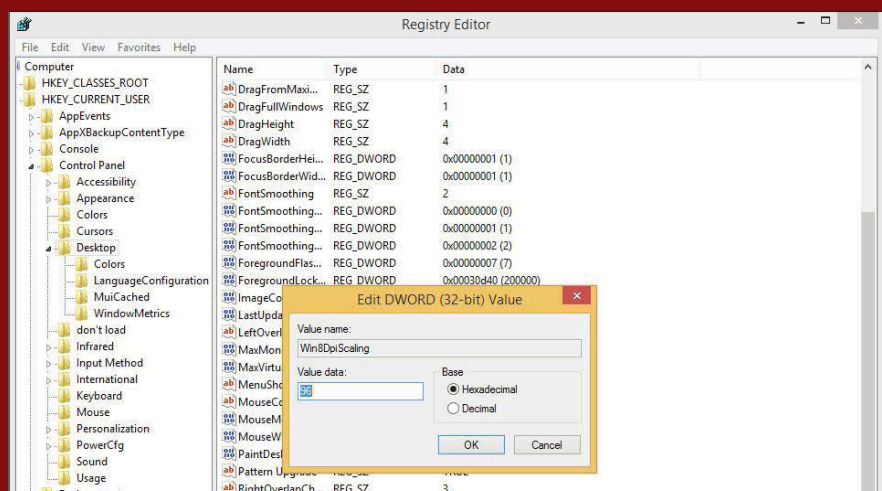
Become The Master Of Your DPI

Here at CPU, we talk a lot about how to build and set up HTPCs, but not much about how to live with them. One of the first things you should do to make the experience as smooth as possible is adjust the DPI (dots per inch) scaling. The goal is to make menus, fonts, icons, and other UI elements large enough that you can see everything from your sofa. To see the DPI settings menu, right-click the Desktop and click Screen Resolution, then click the Make Text And Other Items Larger Or Smaller hyperlink toward the bottom of the window. By default, Windows 8.1's Change The Size Of All Items menu gives you a simple slider that lets you choose Larger or Smaller, which translates to 100% and 150% DPI settings.

To tap into a larger array of DPI settings, you'll have to perform a simple Registry edit. Keep in mind, improperly editing the Registry can severely damage your computer, so triple-check the characters, spacing, and names of the items you're editing before you make any changes. And before you start navigating the forest of folders and subfolders contained within the Windows Registry Editor, you should always perform a backup. To do this in Windows 8.1, go to the Start screen and type **regedit**, then press ENTER to launch the Registry Editor (you can also press Windows Key-R to open the Run dialog, then type the name of the utility). Click Yes if a UAC prompt appears, click File and then Export, choose a location, name the file, and then click Save. Creating a System Restore Point is another good way to prevent a change to the Registry from making your system unbootable. To do this, go to the Start screen and type **create a restore point**, then press ENTER. Click the restore point creating utility icon, click the Create button at the bottom of the System Properties dialog, name the restore point, then click Create.

Back in the Registry Editor, we need to navigate to HKEY_CURRENT_USER\Control Panel\Desktop from the left pane. In the right pane, scroll to the DWORD item titled Win8DpiScaling, then double-click it to open the Edit DWORD (32-bit) Value. There should be a Value Data field that has a 0 in it. Change this to 96 for 100% or "smaller" scaling, 120 for 125% or "medium" scaling, 144 for 150% or "larger" scaling, 192 for 200% or "extra large" scaling, 240 for 250%, 288 for 300%, 384 for 400%, or 480 for 500% scaling.

Although you can set your desired DPI from the Registry Editor like this, the better option is to just input 96 (smaller, 100% scaling), which is the default value, then close the Registry Editor and restart your computer. When you right-click the Desktop and click Screen Resolution, then click the Make Text And Other Items Larger Or Smaller hyperlink toward the bottom of the window, you'll now see Small, Medium, and Larger DPI scaling radio buttons, as well as a Custom Sizing Option hyperlink that lets you choose from eight DPI settings, up to 500%. It also displays a text preview to give you an idea just how much changing the DPI will affect the UI. ■



Upgrades That'll Keep You Humming Along

This month, we found some helpful updates for FotoSketcher, Foxit Reader, Firefox, and Sandboxie, as well as new versions of CPU-Z and CCleaner that better support use with Microsoft's Windows 10 Technical Preview. In our Driver Bay section, there's big news with AMD's latest beta driver, as well as a new version of Intel's Chipset Device Software.

SOFTWARE UPDATES

CPUID CPU-Z 1.72

If you're using CPU-Z with Windows 10 Technical Preview Build 9926, you'll want to use CPU 1.72, as CPUID has fixed a bug that occurred when using this build. Update 1.72 also includes preliminary support for Intel's "Skylake" processors.

www.cpuid.com

FotoSketcher 3.00

FotoSketcher is a utility designed to convert your digital photos into artistic images, such as photos with the look of a watercolor or oil painting, or pen and ink drawings. The 3.00 update adds a brushstrokes effect, as well as an invert colors function. For ease of use, there are now keyboard shortcuts (left, right, and up keys) to move the divider between the left and right panes. A few cosmetic changes were also made to the user interface.

www.fotosketcher.com

Foxit Reader 7.1

This update to Foxit's popular PDF creation and conversion tool now allows for page navigation, by URL parameters, inside a web browser. For better annotations, the 7.1 update also lets you add bulleted lists. Owners of the Enterprise edition receive support for PPDF (Pfile-based PDF) encryption. The 7.1 update also boasts several improvements that you might find helpful, such as the ability to preview signatures and stamps.

www.foxitsoftware.com

Mozilla Firefox 36.0

Firefox 36.0 is the second major release of Mozilla's desktop web browser this year. Support for the HTTP/2 protocol (the first revision of HTTP since 1999) is the big news; the update also allows pinned tiles on the New Tab page to be synced so Firefox users can have the same pinned tiles on all PCs where Firefox is installed. For better security, Mozilla is phasing out certificates with 1,024-bit RSA keys in favor of certificates with 2,048-bit keys (or more.)

www.mozilla.org

Piriform CCleaner 5.03

Here's another update that improves application support for the latest version of Windows 10 Technical Preview. Piriform also added cleaning for Google Chrome's IndexedDB and improved Google Chrome session cleaning. For better accessibility, CCleaner 5.03 comes with improved keyboard navigation and shortcuts.

www.piriform.com

Sandboxie 4.16

You've probably heard of the term "sandbox" to describe a restricted environment where programs run in a virtual container. Sandboxie allows you to sandbox programs, so you can try out unknown or untrusted programs in a way that won't let them make any permanent changes to other programs or data. The 4.16 update features a redesign of the hooking/injection code with ASLR now enabled for 64-bit. Sandboxie 4.16 also offers some fixes, including an issue where Outlook 2013 would crash at start and Excel 2013 would remain in memory after program exit.

www.sandboxie.com

DRIVER BAY

AMD Catalyst 15.3 Beta

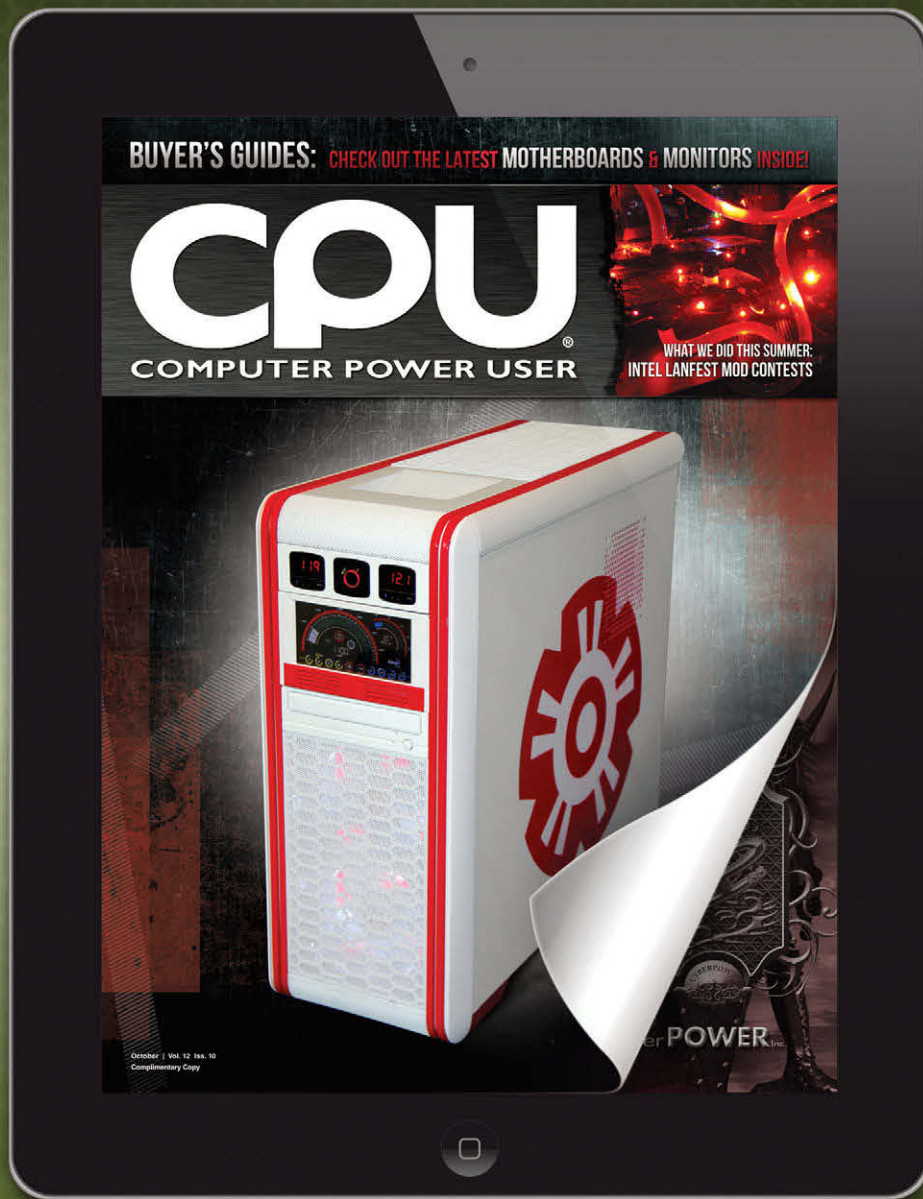
The 15.3 Catalyst beta software suite introduces support for AMD's FreeSync, which is a technology that keeps a GPU's video output in lockstep with how often a FreeSync-compatible monitor draws an image. As such, a FreeSync GPU and monitor should provide you with smoother gameplay and video free of the tearing effect that can otherwise occur. The Catalyst 15.3 driver delivers FreeSync capabilities to a variety of AMD GPUs and APUs, including most of the Radeon R9 and Radeon R7 lineups. FreeSync support in the Catalyst 15.3 beta is currently limited to single-GPU configurations, but the beta does introduce new CrossFire profiles for Battlefield Hardline, Evolve, Far Cry 4, Lords Of The Fallen, Project Cars, and Total War: Attila.

support.amd.com/en-us/download

Intel Chipset Device Software 10.0.26

Intel's Chipset Device Software provides your operating system with information (via an .INF file) about proper setup of the chipset, and it also lets the OS show the correct name for a piece of hardware listed in Device Manager. Version 10.0.26 adds support for Microsoft Windows Server Threshold x64, as well as for Intel Xeon D-1500 product family devices. It also add official branding for Intel Atom, Celeron, and Pentium processor families.

www.intel.com



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Inside The World Of Betas

AUTODESK MEMENTO

Are you interested in 3D printing and want to create your own digital 3D models? Maybe you want a new way to generate high-quality 3D models for a videogame or artwork. Autodesk's Memento beta is designed to simplify the 3D modeling process by preparing large 3D models from images you capture.

To see Memento work its magic, upload a series of photos you've taken of a subject (make sure to capture from all angles and directions), and Memento will start building your 3D model. Memento automatically removes the image background, so the focal point of the image will be the only object that will appear. You can isolate individual elements for removal using Memento's smart selection tools. Memento also features a Diagnostics tool that displays any issues that don't match the rest of the 3D model, such as particles, holes,



spikes, or tunnels, making it easier to find flaws that you might otherwise miss.

After Memento creates the 3D model, you can export it to a variety of formats, including .OBJ, .STL, .PLY, .FBX, and .RCM. Memento can also directly connect to a number of today's 3D printers, allowing it to recognize bed size, method of 3D printing, and hollow meshes. It can

also report, in real time, the volume of used material.

The Memento beta is available for PCs running Windows 7/8/8.1. Autodesk recommends a system with 12GB of memory, a multicore processor, and a graphics card with at least 2GB of VRAM. Creating 3D models has never been so easy. ■

Memento

Publisher and URL: Autodesk;
memento.autodesk.com

ETA: TBD

Why You Should Care: It converts regular 2D photos into high-definition 3D models—no CAD experience required.

RAZER CHROMA SDK

Razer's Chroma lineup of gaming peripherals features customizable LED lighting to let you personalize the keyboard, mouse, and headphones to your liking. For example, gamers can use the Razer Synapse cloud configuration tool to pick and choose which keys, based on game genre, light up on the BlackWidow Chroma keyboard. The Razer Chroma SDK beta lets developers further customize the individual LEDs to respond to in-game actions or situations. MOBA developers, for example, could have the BlackWidow Chroma's keys flash whenever the player's base is under attack or color-code the Q, W, E, and R keys to only light up after a cooldown timer has ended.

The SDK is free to everyone, so you can try it with your own programs if you have C or C++ coding skills. Razer indicates that the Chroma SDK also allows for the creation of standalone



applications that would run natively on the keyboard.

Razer initially rolled out the Chroma SDK beta for use with the Razer BlackWidow Chroma, but future updates will allow the SDK to control all of Razer's Chroma devices, such as the DeathAdder Chroma mouse, Naga Epic Chroma mouse, or Kraken 7.1 Chroma headset.

We can't wait to see what type of ingenious in-game lighting developers come up with. Custom lighting effects that react to in-game actions would add a new level to game integration. The Chroma SDK's support for standalone apps might also appeal to those who want to simply play around with the BlackWidow Chroma's custom lighting. ■

Chroma SDK

Publisher and URL: Razer;
www.razerzone.com/chroma

ETA: TBD

Why You Should Care: This SDK lets game developers and others customize the lighting system on Razer's Chroma lineup of gaming peripherals.

Cable À La Carte

Cord-Cutting Options Multiply

Until recently, one of the biggest disadvantages to cutting the cord has been the loss programming only available over cable or satellite broadcast. Free OTA (over-the-air) television and subscription Internet TV services have been short on content from popular cable networks such as ESPN, AMC, HBO, and others. But with the recent announcements of DISH Network's Sling TV and Sony's PlayStation Vue offerings, as well as standalone streaming services for HBO, CBS, and Nickelodeon, cord cutters have access to plenty of premium content without the need for a cable or satellite contract.

For example, HBO NOW is a new standalone service that lets you enjoy HBO's extensive catalog of original shows and special programming on an iPhone, iPad, Apple TV, or iPod Touch for only \$14.99 a month.

The two-party system that controlled your TV viewing "choices" for so long is facing challenges from a gang of upstarts. Let's tune in to some of the latest virtual cable and IP-based TV options.

TV Evolution

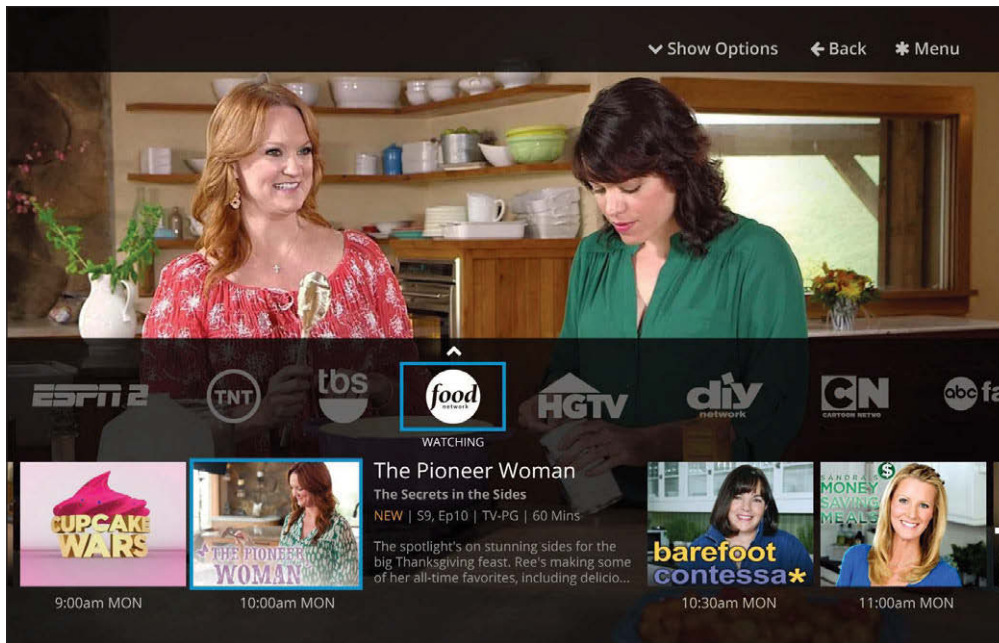
A recent report from Nielsen found that 40% of all U.S. households with a TV and broadband Internet subscribe

to at least one video on demand service and that 13% of households subscribe to multiple streaming services. The most popular OTT (over-the-top) service is Netflix, which can be found in 36% of U.S. homes with a TV. Amazon Prime (13%) and Hulu Plus (6.5%) come in second and third place, respectively. It's clear that many of us have found a role for OTT video streaming services.

The latest developments in Internet TV are geared more toward those without a cable or satellite service agreement, as you'll find programming options for Adult Swim, ESPN, Food



ESPN and ESPN2 are a couple of enticing options reasons for cord cutters to sign up for Sling TV.



Sling TV's Best Of Live TV package comes with many of today's most popular cable channels.

Network, HBO, HGTV, TNT, the Disney Channel, and CBS. Much of the programming on these channels was difficult or impossible view via the initial wave of OTT TV services. In some cases, such as Sling TV, virtual cable options will even allow you to watch channels in real time. "Consumers have shown a desire to watch premium content on their own terms," Glenn Hower, research analyst at Parks Associates.

With access to premium content, networks such as HBO and ESPN can add new revenue streams in addition to providing you new ways to access your favorite programming. "Networks like HBO are discovering that there are revenue opportunities outside the cable TV system," says Hower, "given that there is a sizeable audience—somewhere in the realm of 15% of households with broadband service—that do not subscribe to a pay TV service. Since the pay TV market has reached a point of saturation (and there may even be some net losses), the networks are looking for ways to expand their revenue streams."

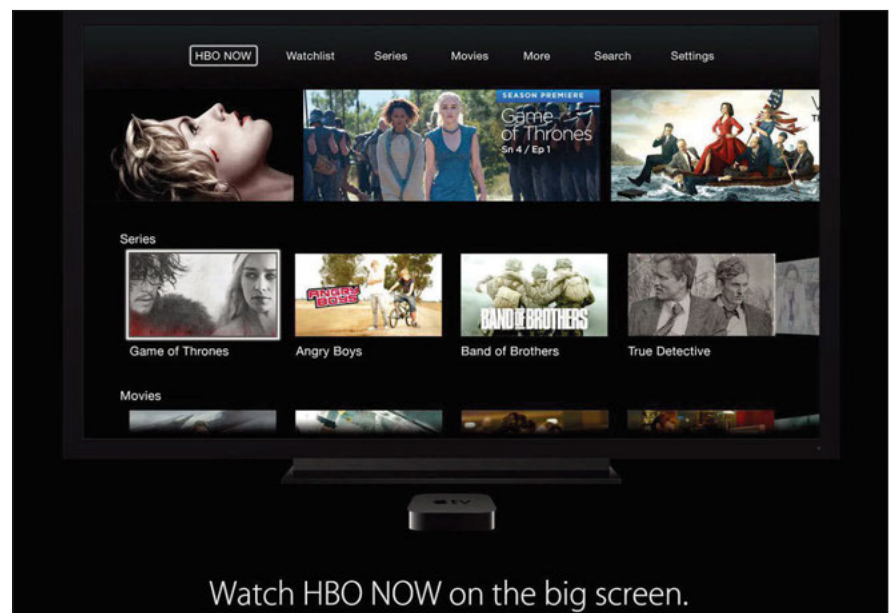
Sam Rosen, practice director at ABI Research, agrees. "Broadcasters and cable

programmers have used multiscreen and OTT services to directly understand the true demand and value of their content. Premium publishers can extract more directly from consumers for their content than they can get as part of a cable or satellite bundle, potentially even

as distributors don't lose out significantly due to increasing broadband demand."

The pricing of a standalone or OTT bundled service will be a key consideration for content owners. "HBO NOW is priced such that they do not feel many customers will leave their current packages just for the HBO service," says Hower. "They are really looking for revenue beyond the pay TV system." The \$14.99 per month subscription for HBO is almost double what you'll pay for Netflix or Hulu's OTT services, so the pricing is a departure from what consumers have started to expect from OTT video streaming.

Although access to premium programming has fueled interest in alternatives to cable and satellite, it's still too early to judge consumer reaction. "Yes, we've seen some interest regarding the announcements, but there's really no traction yet on



HBO NOW provides on-demand access to HBO's most popular shows.



Initially, HBO NOW will work exclusively with Apple products, such as Apple TV.

the individual channels,” says Bruce Leichtman, president and principal analyst, Leichtman Research Group.

Break The Bundle, Break The Bank?

Make no mistake, standalone and bundled IP-based TV services from content owners are not a philanthropic effort. “The à la carte system has long been thought the ultimate model for the consumer, but I have reservations on the viability of this kind of system,” says Hower. “Economically speaking, networks are going to charge what they can get away with to sustain their programming.” Premium channels shouldn’t have much of a problem selling subscriptions to cord cutters, while more niche networks might not be able to support themselves without the help of pay TV.

The cost of the various standalone services could actually end up being a deterrent for some. “I think one of the challenges will be when people start to pile up subscriptions, because they could be building a model that is just as expensive as a traditional cable bundle,” says Leichtman. For example, if you want both HBO NOW (\$14.99/month) and Sling TV (\$20/month), you’ll be paying \$35/month. Add Netflix and Hulu Plus (each \$7.99/month) and you’re up to \$51 per month. The average monthly price for expanded basic cable service was \$64.41, according to findings from the

FCC last year, which defined expanded basic as all the local programming channels and at least seven additional cable network channels.

You’ll also need to account for the cost of your Internet service. Cable and satellite providers often discount Internet service with a bundled TV and Internet package. A “naked” DSL or cable Internet package might increase your monthly ISP bill. “With à la carte TV, it turns out you pay the same for less in most cases,” says Rosen, “although consumers with specific content tastes can win out. Price-sensitive consumers will have one or two subscriptions, potentially rolling on or off seasonally or with hit shows, and all of us will likely consume more digital transactional content (rentals and purchases).”

Sling TV, for instance, could be a good option for cord-cutting sports fans that want to watch live games. The standard Sling TV package gives you access to ESPN and ESPN2, as well as TNT and TBS, which regularly show professional baseball and basketball games. For \$5 more per month, you can purchase Sling TV’s Sports Extra package that gives you ESPNU, ESPNNews, the SEC Network, Universal Sports, and others.

Interest in only the most popular cables channels, of course, is one of the reasons that you might prefer the à la carte system. If you only watch a few channels out of the hundreds available from cable or satellite, you’ll likely be able to get by on a couple of Internet TV subscriptions—and see a big drop in your monthly bill. But if you plan on filling up on the same variety of channels you had access to via cable or satellite, à la carte might not be the best option.

It’s also important to note that virtual cable is still in its infancy. “I think from the provider side, organizations are still in the dabbling

Standalone Or Small Bundles

When you look at the most popular OTT services, such as Netflix, Amazon Prime Instant Video, and Hulu, you’ll find a variety of content from the big networks, movie studios, and independent video. When it comes to virtual cable, partnering up also might be the way to go.

“I don’t anticipate that we’ll see a lot of single channel options, because it doesn’t make sense for the content owners to do that,” says Bruce Leichtman, president and principal analyst, Leichtman Research Group. “I guess you would say that CBS is an exception to that, but the reason is that they aren’t part of the other three big networks that make up Hulu.”

By combining a few of the most popular cable channels together, Sling TV looks to be a compelling bundle. “The slim package system that Sling TV offers probably has some longevity in the market, particularly when bundling popular channels like the core ESPN networks, AMC, and Disney,” says Glenn Hower, research analyst at Parks Associates. “I think the prospect of more slim packages, whether over-the-top or through a managed network, are possible. Standalone mini subscriptions could be a harder sell, unless there’s a strong demand for the content, such as “Game of Thrones” and other HBO original shows.

mode, where they are seeing what’s out there,” says Leichtman. “I think all the content owners want to see how they can leverage their content.” The higher the cost, the less likely the virtual cable options will appeal to those looking to get away from pay TV.

Pay TV Gets In The OTT Game

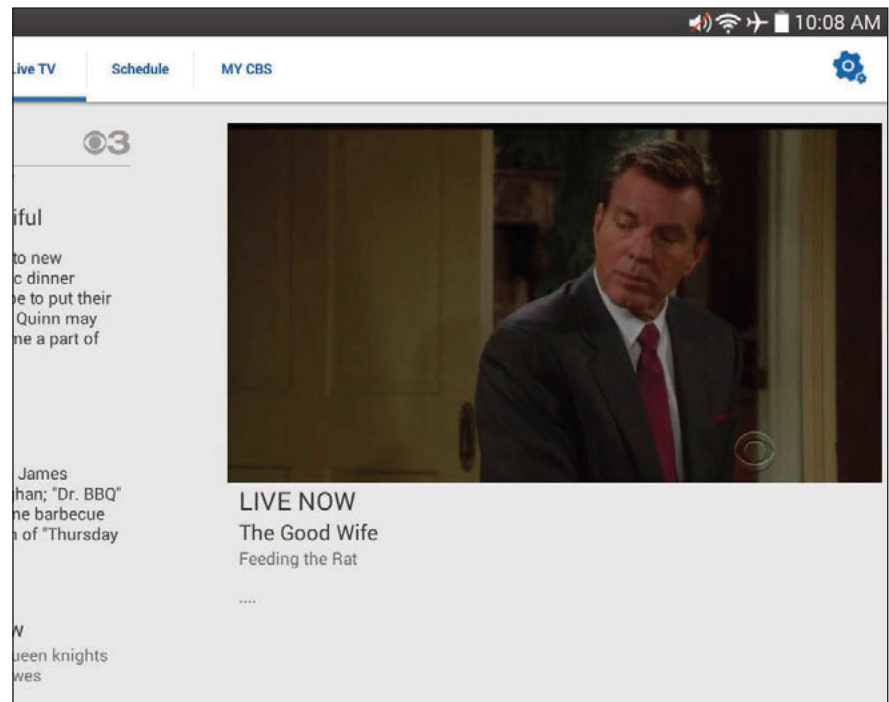
Since 2013, the leading pay TV providers have only lost about 0.2% of their subscribers, according a report from



CBS All Access lets you enjoy on-demand CBS programming on a multitude of devices.

the Leichtman Research Group. The report examined the 13 largest pay TV providers, which collectively hold about 95% of the market, and found they lost about 125,000 total video subscribers in 2014. The numbers are similar to the drop seen in 2013, when pay TV lost 95,000 subscribers.

One of the ways that TV providers have managed to maintain a strong subscriber base is the addition of authenticated video on demand (frequently called “TV Everywhere,” although this is the same name as Time Warner Cable’s proprietary service), which lets you stream programming to your mobile devices and computers. Comcast’s XFINITY, for example, lets you stream a wide variety of movies and TV shows, as well as live programming, based on the channels available via your XFINITY subscription. This way, you can watch your favorite shows when you’re away from home. Similar



In certain markets, CBS All Access provides access to live, local programming.

options are available for Time Warner Cable, Verizon, and CenturyLink. Value-added services like authenticated video on demand help providers keep pace with the viewing habits of today's consumers.

"DVRs started breaking people's behaviors around appointment viewing, which is now important only for live or high-demand social viewing," says Rosen. "VOD services have led to new phenomena—from binge viewing to expectations of ad-free, interruption-free TV." OTT and Internet video services from pay TV providers make it easy to catch up on your favorite shows.

That being said, reinventing pay TV to provide IP-based, on-demand video to any screen could be challenging for some providers. "Pay TV middleware vendors will need to be extremely nimble and focus on providing agile solutions that allow service providers to compete with OTT services," says Frost & Sullivan digital media industry analyst Hiral Jasani. "They must direct attention toward open-source middleware, as this has proven to be a successful strategy for middleware vendors and operators alike."

A big benefit of the authenticated video on demand options is that most extend their timeshifting capabilities to



The Noggin app provides subscription access to many of Nickelodeon's most popular archived shows.

the premium cable channels you subscribe to. If you don't have time to watch your favorite show when it airs, on-demand access to premium channels could be a big draw, letting you catch up during the daily subway commute or over your lunch break. Additionally, some TV Everywhere services can provide access to live programming, including sporting events. Time Warner Cable's TV Everywhere service, for example, also includes access to ESPN, Big 10 Network, Pac-12 Network, MLB.tv, NBA LeaguePass, and FOX Sports GO.

If your family watches a wide range of programming, a pay TV provider's TV Everywhere services might be more cost-effective than a collection of standalone or OTT services that deliver the same

content. And like an OTT service, you'll still be able to watch what you want, when and where you want.

Timeshifting With Virtual Cable

The recently announced virtual cable subscription services include some timeshifting capabilities, too. CBS All Access provides over 6,500 episodes of its programming library, including current seasons of its popular shows, such as "The Good Wife," and past hits, such as "MacGyver." Sling TV indicates that its service comes with a 3-Day Replay feature

for certain channels, so you can watch recently aired shows without the need for a DVR. If you're looking for on-demand entertainment for the kids, Nickelodeon's Noggin app is designed to deliver children's favorites, such as "Blue's Clues," to mobile devices.

Combine OTA With OTT

OTT services and streaming devices are great for watching most TV shows on your own schedule, but this combination might not give you access to everything you want to watch. For example, Netflix and Amazon Prime Instant Video don't usually offer the current seasons of third-party TV shows, though Amazon does offer deals

"Pay TV middleware vendors will need to be extremely nimble and focus on providing agile solutions that allow service providers to compete with OTT services."

-Hiral Jasani, Frost & Sullivan digital media industry analyst

The Perils Of Live Broadcast

Live streams of IP-based TV can be a challenge to deliver on a mass scale. "It is much less feasible to put a live stream over the open Internet in a packet-switched system than it is to feed video either over the air or through a managed network," says Glenn Hower, research analyst at Parks Associates. "This is where you begin to encounter quality of experience issues like pausing and buffering." IP delivery of on-demand content, which allows for buffering, is able to better deliver the visual quality viewers have come to expect.

Sling TV offers an assortment of live channels, but it may be the outlier rather than the norm. "Networks like ESPN [ESPN3] DISH [Sling TV] have shown some early success in this regard, but putting together a live video stream that can scale is a massive undertaking that requires copious resources," says Sam Rosen, practice director at ABI Research. The increased difficulty means that live viewing might only be an option for premium channels and/or the biggest events. "Ultimately, it is major sporting events (Olympics, World Cup, Super Bowl) that have driven the majority of live viewing over the last few periods," says Rosen.

(such as season passes) to rent or buy the latest episodes. Hulu Plus is great for catch-up viewing, but complete current seasons are not always available. If you have a network TV show that you absolutely must watch, you can invest in an antenna to gain access to live, local TV stations. Best of all, OTA signals are free, and almost all TV stations now broadcast in HD.

For the best quality viewing experience, you'll want an antenna that has excellent reception. "There are some great resources for determining what kind of antenna you need, such as set-top, attic, rooftop, amplified/non-amplified," says Hower. "The FCC has consumer resources and guides, and there are third-party websites like TV Fool [tvfool.com] that aggregate broadcast data so consumers can determine signal strength and transmitter location to best set up their antenna." For example, you can visit transition.fcc.gov/mb/engineering/dtvmaps to check the signal quality in your geographic location.

There are a couple of good options for those that want to supplement their OTA programming with DVR functionality. Channel Master's DVR+, for instance, is a set-top box with two tuners to capture OTA broadcasts and let you pause, rewind, and fast forward recordings. There's a 16GB model (\$249), which is designed to work with a USB external hard drive, and a 1TB version (\$399) with plenty of built-in storage.

The initial price might seem steep, but it does provide subscription-free DVR, among other benefits.

"An OTA DVR from Channel Master can combine with a Slingbox to stream both live broadcasts and stored content to any connected device or PC," says Michael Inouye, senior analyst at ABI Research.

Power users, of course, have long been using HTPCs with TV cards to capture OTA signals. If you have an old build sitting about the house, repurposing it as an HTPC can expand your entertainment options after you've cut the cord. If you want to distribute an OTA signal to multiple computers and tablets throughout your home, consider an HDHomeRun from Silicon Dust. This line of network-connected TV tuners receives the OTA signal from your antenna and pipes it over your home network to PCs, videogame consoles, and mobile devices. At \$129.99, the HDHomeRun CONNECT is comparable to what you'd pay for a single TV tuner card.

Sling TV

Widely hailed as the "cord cutter's dream come true," Sling TV delivers the live programming you might have missed (or will miss) when you cut cable or scrap satellite. The Best Of Live TV Package (\$20/month) has something for just about everyone. Popular shows are well covered, with the inclusion of networks such as

AMC, TBS, TNT, Adult Swim, and IFC. Home improvement junkies can watch HGTV and videos from Maker Studios, while kids can watch ABC Family, the Disney Channel, and Cartoon Network. The Best Of Live TV Package gives sports fans access to ESPN and ESPN2.

Sling TV also offers add-ons packages you'll want to consider if you enjoy specific genres or movies. The Hollywood Extra package comes with several EPIX channels and Sundance TV, while Kids Extra adds Disney Junior, Disney XD, Boomerang, Baby TV, and Duck TV. Other packages include extra news and lifestyle channels, respectively. Each add-on package adds \$5 to your monthly bill.

You can watch Sling TV on your mobile devices and PCs, as well as on your big screen via Amazon Fire TV and Roku devices. Sling TV also says that support for Google's Nexus Player and the Xbox One is coming soon. At the time of this writing, Sling TV was offering discounts on Roku and Amazon Fire TV devices if you prepay for three months of Sling TV. If you're ready to cut the cord and need a device to access your other OTT services, now's the perfect time to enroll.

A seven-day trial is available, and Sling TV doesn't require a service contract, so you won't be locked into a long-term commitment. As such, you could sign up whenever one of your favorite shows is starting and cancel when it's

over. Football fans could maintain the subscription during the season and drop it after bowl season. Currently, Sling TV is limited to one device at a time, so you'd need multiple subscriptions if your family wants to watch two shows at one time.

HBO NOW

HBO is launching its standalone streaming service this April, just in time for "Game of Thrones" fans to see the fifth season. At launch, HBO NOW will be available via iOS devices and directly on Apple TV, the latter being ideal for watching on the big screen. You can subscribe to HBO NOW using your iTunes account. Apple has reduced the price on its Apple TV from \$99 to \$69 to help promote the service. Critics might say that Apple's exclusivity deal means consumers are still forced to make certain buying decisions in order to get HBO: Instead of subscribing to a cable or satellite provider, they'll need

to own Apple hardware. Eventually, HBO will make HBO NOW more widely available.

With HBO NOW, the network promises to provide on-demand access for every episode of its programming, as well as access to the latest movies, documentaries, and specials. In addition to "Game of Thrones," currently running series include "True Detective," "Girls," "Veep," "Silicon Valley," and "The Leftovers." HBO's greatest hits, such as "The Sopranos," "Sex And The City," "True Blood," "The Wire," and "Deadwood," will also be available. In terms of special programming, you'll be able to watch shows "Last Week Tonight With John Oliver," boxing events, and HBO Sports documentaries.

If you were a fan of HBO's programming but lost the service when you dropped cable, HBO NOW is an excellent alternative to "borrowing" your parents' HBO GO account info.

CBS All Access

Besides the being able to cue up those 6,500+ episodes of CBS programming, CBS All Access is also designed to let you watch your local CBS affiliate on your favorite mobile device or PC. Currently, the live broadcast capability is limited to a few regions, but CBS has recently come to terms with the CBS Affiliates Board to provide local stations with a portion of the subscription fee. With more local stations onboard, live broadcasts via CBS All Access should be available in more markets in the near future.

Because Hulu doesn't have access to currently running CBS content, cord cutters that can't watch CBS via OTA signal might find that CBS All Access is a good fit. The \$5.99 monthly fee is even more appealing if you're able to receive live local programming, which could include sports fan favorites such as the NCAA Men's Basketball Tournament,



The HDHomeRun line of connected TV tuners distribute over-the-air signals from an antenna to devices on your home network.



PlayStation Vue is a TV service currently designed for use on Sony's PS4 and PS3.

PGA tournaments, NFL games, and college football. CBS is offering a one-week free trial, if you want to check out the service and see if it's something you'd want in an à la carte package.

Nickelodeon

In early March, Nickelodeon released its Noggin app that provides subscription access (\$5.99 a month) to programming developed for preschoolers. Children can watch shows such as "Blue's Clues," "Little Bear," and "Ni Hao, Kai-lan." The app can also play education and music videos, which will help kids to learn letters, shapes, matching, and other skills.

The Noggin app is available for iOS devices via Apple's App Store. The titles available at launch, which don't include Nickelodeon's current lineup, are intended to complement the content found on the Nick Jr. app, which requires pay TV authentication and delivers a live, linear feed of Nickelodeon programming.

Sony PlayStation Vue

If you own a PS4 or PS3, you can now subscribe to Sony's PlayStation Vue service. Initially announced back in November 2014, PlayStation View promises to let you save your favorite shows in the cloud and schedule recordings from around 75 channels per market. The service has launched commercially in New York, Chicago, and Philadelphia and should roll out to other cities over the course of the year.

Sony has already established quite a few network partners, including CBS, FOX (including local Fox stations plus FX, FOX Sports, and Big 10 Network), NBCUniversal (including local NBC affiliates, Bravo, CNBC, Oxygen, Sprout, Syfy, and USA Network), Viacom properties (Comedy Central, MTV, and Nickelodeon), and Scripps Network Interactive networks (HGTV, Food Network, Travel Channel). At the time of this writing, Sony had introduced

three tiers—Access (\$49.99/month), Core (\$59.99/month), and Elite (\$69.99/month), with each tier adding more channels than previous tiers. Similar to Sling TV, there will be no contracts and no need to rent any additional equipment—other than the required broadband Internet service and a PS4 or PS3.

A Lot Of Ways To Watch TV

The new wave of virtual cable options fill a huge need for cord cutters. No longer is Internet TV limited to catch-up viewing options for network TV and movies that have long been rentable. Sling TV, HBO NOW, and CBS All Access, among others, provide access to live, premium content that may prove compelling enough that cord cutting will no longer be just a movement, but the norm. If successful, the à la carte options might also force the hand of pay TV companies to change how premium bundles are offered. All we can say for now is that it's a good start. ■

Ethical Hacking 101

Find Flaws, Save Businesses

Have you ever thought about a career as a hacker? We're not talking about making money from criminal or unethical behavior, but rather, working as an "ethical" or "white-hat" hacker whose goal is to penetrate an organization's computers and network security to discover and disclose vulnerabilities.

"Ethical hacking is the art and science of applying hacking techniques to try to improve the security of target systems," says Ed Skoudis, curriculum lead for penetration testing at the SANS Institute. "By using the same tools, tactics, and procedures of real-world bad guys, ethical hackers work to help an organization better understand its business risks and mitigate the most significant risk."

Would You Like To Know More?

An ethical hacker's job description is pretty close to what a criminal hacker does. But once they've broken in, the white hat will report the results to the organization. "They hack through responsible disclosure, or as a result of bug bounty programs, or simply as part of their jobs (among others, pentesting is probably the most well-known)," says Michela Menting, ABI Research practice director. With things like bug bounty programs, an ethical hacker's goal is to work within specific parameters to find flaws and/or vulnerabilities and report them back to the company.

"Responsible disclosure is when there is no specific bug bounty or demand from a company to find flaws, but some are found nonetheless," says Menting. "A White hat or ethical hacker will disclose the bug to the company and not publish the feats (or only publish once the company has patched)." So-called "grey-" or "black-hat" hackers wouldn't necessarily disclose the vulnerability to the company, but they would publish their feat, or disclose it as they see fit.

If hired by a company for penetration testing, an ethical hacker's job is to find



SANS Institute events allow you to receive hands-on training from instructors, who are also real-world practitioners.

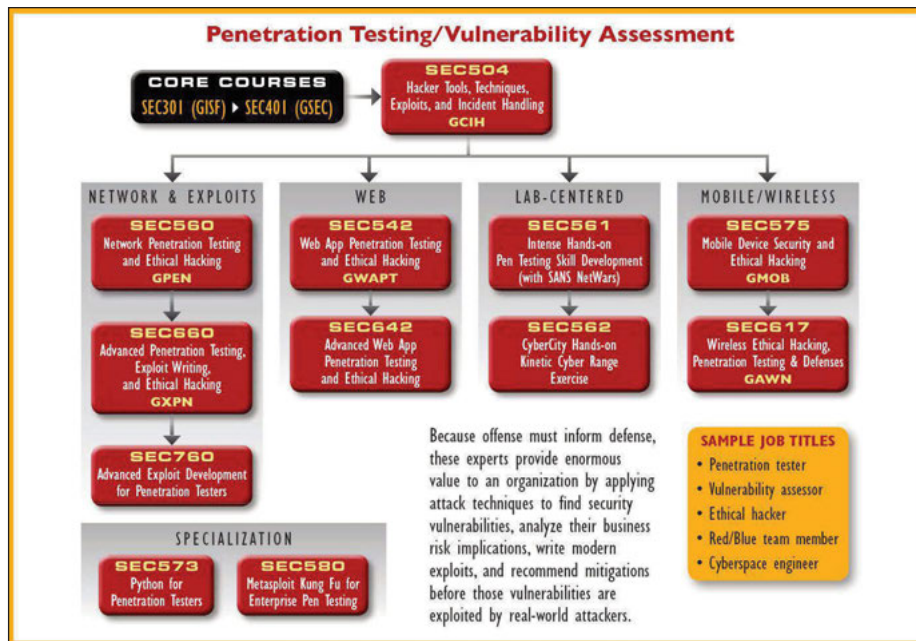
vulnerabilities before someone else does. Skoudis says "By conducting a mock attack against an organization, hackers for hire can find flaws and make recommendations for mitigating them before disaster strikes." Based on the findings, an ethical hacker will help a company to identify risk management issues, help to prioritize resources, and make more secure business decisions. "Rather than merely showing theoretical vulnerabilities, ethical hackers can help an organization see where the rubber meets the road, with specific areas they can be breached," says Skoudis.

The Code Of Conduct

The GIAC, which is one of the organizations that grants certifications, has a code of ethics that it expects certified professionals to uphold. Parts of the code are things that you'd expect, such as "protect confidential

and proprietary information with which I come into contact" and "minimize risks to the confidentiality, integrity, or availability of an information technology solution, consistent with risk management practice." Any who are found to have violated the ethical principles can be subject to disciplinary action from the GIAC.

The SANS Institute, an organization that specializes in information security training, also has several informal principles that they want students to adhere to, including items such as "Don't hack without permission of the target system owners and operators" and "Do no harm—exercise extreme caution so that you don't cause systems to crash." The SANS Institute also expects graduates go beyond the basic scan results to find flaws that innovative criminal hackers would try to exploit, so you're providing a truly valuable service to the organization.



The SANS Institute offers a variety of courses to train you for GIAC certifications in penetration testing, among other fields.

Learning The Skills

There are several training programs, such as the SANS Institute (www.sans.org) and the EC-Council (www.eccouncil.org), that offer courses to help you become a certified hacker, penetration tester, or other IT-related security expert. Similar to other forms of higher education, people looking to join a certification program will benefit from having a strong foundation of upon which to build knowledge.

Skoudis points out that professional penetration testers rely on numerous skills, including “A deep understanding of computers, operating systems (Windows and Linux especially), and networking (TCP/IP in particular).” It’s also helpful if you have a familiarity with the most powerful hacking tools, which might include Nmap, Metasploit, and the Burp Suite.

Those wishing to become licensed penetration testers would do well to have some knowledge of how IT staff administer computer systems and ways to exploit the systems. For example, it’d be helpful to know the most common computer vulnerabilities and ways a business could mitigate risk. With the ability to assess the security posture of a system, you can better identify ways that

potential hackers could launch an attack. Lastly, Skoudis says “knowledge of how to write code is helpful, but not essential.”

Now, you don’t have to be an IT expert to take the courses, but it does help to have a basic knowledge of the underlying topic for many classes. We found that most training programs offer core concept classes that introduce the concepts and terminology you’ll need to know in case there are areas where your knowledge isn’t as deep. Some programs also offer evaluation tests to help you figure out what classes you’ll need to take. If you find the topics in the questions are new to you, or that you just don’t know many of the answers, it’s advisable to take an introductory course that will fill in your knowledge gaps. Once you gain the skills you need, you can move into advanced courses.

On the flip side, those with extensive practical experience might not need to take formal courses at all. Some organizations that grant information security certifications don’t require that you pass any specific training before you take the exam, so experts could receive accreditation in only the time it takes to do the exam and receive a passing grade. Other certification organizations, such as the EC-Council, might require you to submit an

exam eligibility application form before allowing you to take an official exam without official training.

What You’ll Learn

“A good training program leading to certification will help underscore the goals, methodology, tools, and specific techniques that security professionals need to conduct an effective ethical hacking engagement,” says Skoudis. Course outlines vary by the type of certification you’re trying to attain, but you can be sure that the courses will prepare you to pass a certified exam.

The EC-Council’s Ethical Hacking And Countermeasures course, for instance, will teach you how to scan, test, hack, and secure computer systems. It’s a five-day class designed to prepare you for the EC-Council’s ANSI-accredited Certified Ethical Hacker exam 312-50, which you have the option to take on the last day of training. Specific topics include how perimeter defenses work, ways to attack networks (where no real network is harmed), how intruders escalate privileges, and the steps you can take to harden the system, to name a few.

Similar to a getting a college degree, most certification programs will have a curriculum that you can follow for a specific career path. The SANS Institute’s Cyber Defense curriculum, for example, offers three levels of classes that can net you variety of certifications, assuming you pass the exams. At level 1, you could take Intro To Information Security that will help you to earn the GIAC’s Information Security Fundamentals certification. The course at Level 2 is Security Essential’s Bootcamp Style, which can help you to earn the GIAC Security Essentials certification.

With these introductory classes done, you’ll have the foundation to take Level 3 classes that can provide the knowledge needed to become a GIAC Certified Enterprise Defender, Certified Perimeter Protection Analyst, Certified Intrusion Analyst, Certified Windows Security Administrator, or Certified UNIX Security Administrator.

The EC-Council provides a similar path for IT certification and training.

Courses offered by the EC-Council can help you to become certified for a variety of careers beyond certified ethical hacking, including a computer hacking forensic investigator, certified security analyst, and licensed penetration tester. You can take a combination of courses to become a certified specialist.

One of the most specialized ethical hacker fields is penetration testing. "There are several different penetration testing certifications available today," says Skoudis. Just some of the individual GIAC certifications include GWAPT (focus on web applications), GXPEN (focus on exploitation with advanced penetration testing), GMOB (testing of mobile devices and apps), and GAWN (evaluating wireless infrastructures). Skoudis says, "Each of these certifications shows that you have the base skills and methodology understanding to provide penetration tests in the given area."

Employment Options

If you don't already have a job in IT, the certifications can help you to land a job. "Many large organizations (such as banks, .gov agencies, and more) have in-house penetration testers to evaluate different business units regularly," says Skoudis. If you do currently have a job in IT, you can use the certifications you've gained to move up in the organization's security group. For instance, you could inform management that you're interested (and qualified) in helping with vulnerability and penetration testing.

"There are many companies that provide third-party penetration tests to other organizations," says Skoudis. A large organization that focuses on penetration testing is a good place to gather experience. You might also be able to find regular work as a freelance ethical hacker. "The demand for certified ethical hackers is certainly high, and they can be costly," says Menting. You could start your own business and offer your services to local businesses that require vulnerability assessments and have no IT staff that can handle the job.

A Professional Team Member

In addition to the technical knowledge required to analyze a network, it's important

that you can put together a good report that will help the organization clearly understand the risk. "Once a business better understands the security risk posture, the organization can spend the limited resources most effectively to address the highest risk vulnerabilities," says Skoudis. Evaluating the organization in an effective manner can also help to set yourself apart from the field and garner good references.

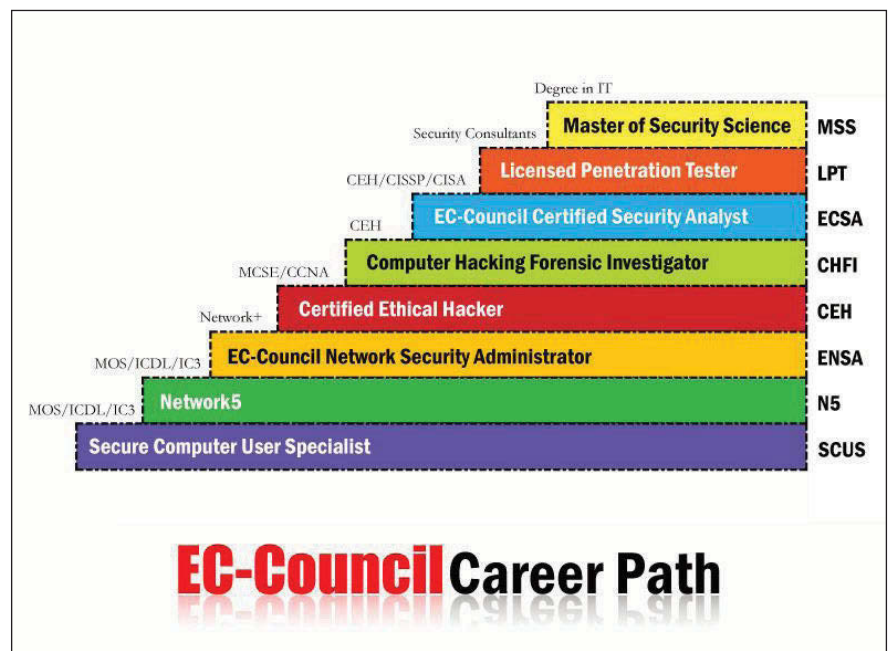
In many cases, ethical hackers and penetration testers will need to work with an existing security team to implement fixes based on their findings. "Penetration testers shouldn't work in a vacuum, nor should they take their findings and just throw them over a wall," says Skoudis. "Instead, the best pentesters are focused on the operational impact of their work and being part of the team focused on helping improve the organization's security stance." You'll want to avoid any situation where you'd become perceived as someone who's just showing where others have screwed up.

Generally, ethical hackers also avoid impacting the availability of systems, so you'll often need to work hand-in-hand with an operations team to configure

monitoring tools and gain access to data. Most ethical hackers use carefully vetted tools and follow a known methodology to provide the business with a better understanding of your methods. Following best practices will also help an operations team to provide you with access to what you'll need to test. In some cases, you might require measured access to sensitive data, such as personal identification or health care data, to test the resources for vulnerabilities. In such situations, it's critical that an ethical hacker follow the code of conduct and access only enough to information to determine the business risk.

Ethical Hacker Certifications

Moving into the world of ethical hacking all starts with certifications. Most businesses looking for someone to test network and computer security want to ensure you have bona fide technical capabilities. If you want help attaining those accreditations, you should check out education programs, such as the SANS Institute or EC-Council. "A good training program will get you ready to conduct an actual project that provides good insights and business value to the target organization," says Skoudis. ■



There are a variety of EC-Council certifications you can attain to specialize your expertise to employers.

Look For *CPU* At These LAN Parties

03.14-15.15

BoiseLAN 1.0

Nampa, ID

www.boiselan.net

03.20-22.15

SalukiLAN

Carbondale, IL

www.salukilan.com

03.21.15

CEG Winter LAN 2015

Big Rapids, MI

ceg.ferris.edu

03.28-29.15

Ultimate Gamers Showdown 2

Dauphin, MB

www.aybonline.com

03.28-29.15

Naois Gaming

York, PA

www.naoisgaming.com

04.04.15

The LANDownUnda

Prattville, AL

www.facebook.com/tricountyland

04.10-12.15

Exodus LAN 2015

Troy, NY

www.exoduslan.com

04.11-12.15

AYBO WonderLAN 2

Winnipeg, MB

www.aybonline.com

04.17-19.15

LANFest Sacramento

Spring 2015*

Folsom, CA

lanfest.intel.com

04.17-19.15

VectorLAN 6

Portland, OR

pdxlan.net

04.17-19.15

AWOL LAN 25

Eau Claire, WI

www.awollan.com

04.17-19.15

University of Wyoming Spring LAN

Laramie, WY

www.uwyo.edu/infotech/lanparty

04.18-19.15

Boilerfrag 8.0

West Lafayette, IN

www.facebook.com/purduegamers

04.18.15

For LAN Sakes Let's Play

Towanda, PA

www.forsakenempire.com

cpu®

Across The Nation—& Beyond!

* Event scheduled to include a *CPU* case mod contest

04.24-26.15

SanDiegoLAN.net Spring
LAN-A-THON 2015

San Diego, CA

www.sandiegolan.net/lanathon.html

04.25-26.15

NeXus LAN

Miamisburg, OH

www.nexuslan.org

04.25-26.15

RIT's Spring LAN

Rochester, NY

www.egsrit.com

05.01-02.15

Indiana Tech Ultimate LAN Party

Fort Wayne, IN

iitgamers.com

05.02-03.15

LANified! 20: Jungle Jukes

Calgary, AB

www.lanified.com

05.15-17.15

AYBOnline Baselan 28

Winnipeg, MB

www.aybonline.com

05.16-17.15

Parlor City LAN

Bluffton, IN

www.parlorcitylan.org

05.22-24.15

LANFest Atlanta Summer 2015*

Atlanta, GA

lanfest.intel.com

07.04-05.15

LANified! 21: Summoner's Stand

Calgary, AB

www.lanified.com

07.17-20.15

PDXLAN 26*

Portland, OR

pdxlan.net

07.17-19.15

Ancient City Con 9

Jacksonville, FL

www.ancientcitycon.com

07.23-26.15

QuakeCon 2015*

Dallas, TX

www.quakecon.org

10.31-11.01.15

Naois Gaming

York, PA

www.naoisgaming.com

11.06-08.15

PDXLAN Charity Event

Portland, OR

pdxlan.net

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Q&A With Shannon Robb

Thermaltake's Marketing Manager On Two New Products

Q : Thermaltake recently launched a new Tt eSPORTS mouse, the VENTUS X. How would you describe the VENTUS X for those who haven't seen it?

SR : The VENTUS X's tagline says it all: "Classic Shape, Modern Tech." Literally, we took a classic shape and we improved the internals to make what was already a great mouse something truly epic!

Q : What is the benefit of the honeycomb-style ventilation on the VENTUS X's palm rest/outer shell?

SR : By breaking up the palm area of the mouse, it helps your palm not have just a smooth surface that will accumulate sweat and cause possible grip issues. It allows natural airflow to reach your palm and reduce sweating and possible buildup.

Q : How do the VENTUS X's design and features contribute to long-term user comfort?

SR : The natural curve of the mouse is made in such a way that your hand can rest at a comfortable angle when using a palm grip, but the angle is not so strong that it alienates fingertip or claw gamers. It really makes the mouse a more universal fit while keeping a very solid feel.

Q : The VENTUS X has three 4.5-gram weights in a compartment on its underside that players can take out as desired to adjust the feel of the mouse. How did your design team arrive at the 4.5g weight per unit, and is this a popular feature among Tt eSPORTS customers?

SR : The mouse is designed so that at its maximum weight (with all weights installed) it achieves a pretty popular weight based on customer and pro team feedback.



But we also know that some really prefer a super lightweight mouse, so when the weights are removed you can get that kind of a feel. Over time we have found that the 4.5g weights offer sufficient steps to allow gamers to get the exact feel they want.

Q : How important is striking the right balance between too few and too many buttons on a gaming mouse, and did your team solicit user feedback on the number and placement of buttons on the VENTUS X?

SR : The ideal number of buttons and placement changes from user to user, so basically we collect feedback especially from LAN events where gamers go and play for long sessions. This is a great resource, and also we collect feedback from customers who buy our products and even our pro teams. With this info in hand, we can make better choices to always improve our next mouse offering.

Q : Can you talk about the VENTUS X's software and what kind of things users can do with it?

SR : The VENTUS X software allows full control over the lighting, lets you adjust performance (such as DPI steps and many other options), and lets you custom-map the buttons for extensive macro functions to match your gaming needs. Also, with the internal 128KB of memory, you can store up to five different profiles to allow easy setups for each game or style configuration directly into the mouse.

Q : Thermaltake also launched a new series of case fans recently; what can you tell us about your Riing-series fans?

SR : The Riing fans are designed to be functional with a major style accent via the integrated light ring.

Q : In layman's terms, what is a "static-pressure" design, and what kinds of uses and placement are Riing fans best for?

SR : The Riing fans can technically be fit in any application, but generating higher static pressure allows a fan to push air through dense fin arrays, such as when mounted to a radiator, so I could see these being used in some monster push/pull setups. With that being said, we made sure that the fan is designed in such a way that even non-liquid-cooled rigs can use these for cooler applications or even case fans, just expect to have a bit more pressure than you may feel from your previous case fan.

Q : Does Thermaltake have plans to expand the Riing fan family to include larger-sized fans, like 180mm or 200mm units?

SR : We are always looking at what other options we can offer, and seeing as how you saw our 180mm-based radiators at CES, well . . . I'll just say, "You have to wait and see!" ■

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